J. ISSAAS Vol. 24, No. 2: 56-69 (2018)

OPERATIONAL PERFORMANCE AND ECO-EFFICIENCY OF BAG PRODUCTION FROM RECYCLED AND REJECTED TETRA PACK MATERIAL IN UGONG, PASIG CITY, PHILIPPINES

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(Received: April 28, 2018; Accepted: November 7, 2018)

ABSTRACT

Operational performance and ecological efficiency of bags made from recycled and factory-rejected tetra packs were evaluated to determine their impact on the environment, particularly on water and air. A total of 81 (41% of the total active members of the KILUS Multi-Purpose Cooperative (KILUS) respondents were personally interviewed on the details of their production processes including wastes generation and management. The process flow of production from two kinds of materials (used tetra pack and factory-rejected tetra pack material) as well as the inputs to and outputs from various production stages were determined. Bag production using both materials was found to be profitable. Used tetra packs are washed three times before bag production and laboratory testing of waste water from the three washes was conducted to determine their biological oxygen demand (BOD), chemical oxygen demand (COD), *E. coli*, pH, total nitrogen and total phosphorus. Water before washing was also laboratory-tested to serve as control. Laboratory results revealed greater than normal BOD but such is easily remediable by performing another round of washing before proceeding with the production process. KILUS as the producer should also ensure that waste water from the first three washes is used only for watering ornamental plants and not food crops. Contaminated water should be prevented from reaching a body of water without proper treatment for reduction of BOD. On the other hand, waste water from the fourth wash can be released anywhere else.

Key words: environmental impact, recycling, waste management

INTRODUCTION

Wastes are substances or objects which are disposed of or/are intended/required to be disposed of as provided by law. They could be domestic, commercial or industrial wastes especially common as co-disposal (Caturao 2009). Most local government units and urban agencies have, time and again, identified solid waste as a major problem that has reached proportions requiring drastic measures. There are three key trends that are observable with respect to solid wastes: increase in volume of wastes generated by urban residents; change in the quality or make-up of wastes generated; and the disposal method of wastes collected (e.g. landfill and incineration, among others). In terms of change in make-up of wastes generated, tetra packs are becoming more and more visible both at the household and institutional levels. Tetra packs are containers made from cellulose (75%), low density polyethylene (20%), and aluminum (5%) (Martinez-Lopez et al. 2015), shaped into a box to contain milk and other drinks. They have gone so popular that they are even used as replacement for tin cans as primary packaging for processed meats, fish, and preserved fruits. Tetra-packed food products have become mainstays among many Filipino households, rich and poor alike, especially in the urban areas where life is a rat-race and elaborate food preparation is sacrificed because of time constraints.

They are however, more popular for use in juices not only for convenience but for environmental protection as well. Despite their growing popularity, not everyone has positive things to say about these juice boxes. Environmental groups are worried that these packaging materials would overwhelm landfills because they are non-degradable and are not as easy to recycle as other types of packages. Along with the volume and variety of juice drinks in the country, the wastes generated by the juice industry along its supply chain in the form of used juice boxes or tetra packs also increased. Innovations however, have not been lacking as more enterprising individuals were able to come up with bright ideas on how to capitalize on the durability and uniqueness of these materials by converting them into durable products that are unique and environment-friendly. The move is seen as timely and strategic because aside from removing these wastes from the environment, income from the sales of the recycled products is also being generated. In 2002, marketable products out of 15.5 tons of these tetra packs have been produced by KILUS Multipurpose Cooperative and they are expected to be doubled in the near future.

The Philippines as one of the most populated and polluted countries in Asia is now facing a big challenge on how to address the problem of mounting solid wastes hence Republic Act No. 9003, also known as the Ecological Solid Wastes Management Act of 2000 was enacted. The Act mandates the adoption of a systematic, comprehensive and ecological solid waste management program to protect not only the health of the people and the environment. Consequently, several projects on solid wastes management were launched, some are well under way and became successful, but many have failed. The ability then of the people who are managing these projects to properly manage wastes remains a question. In addition, Sapuay (n.d.) claimed that "One of the most forgotten issues in the implementation of RA 2003 is minimization at source." In response to this, recycling can be done. Recycling is the process of collecting and processing materials previously discarded but could still be turned into new products (US-EPA, n.d.). Bustamante (2001) shared the seven guiding principles of solid waste management two of which are most relevant in the context of this study: a) waste is a resource and b) waste prevention is better than waste regulation and control. Recycling is consistent with this and can therefore benefit both the community and the environment.

It should be noted however, that even if reuse and recycling are being practiced as a form of solid waste management, performance of such may have environmental impacts or ecological footprints as well. Tetra packs are one of those that need special management techniques since they are non-biodegradable and do not burn at low temperature. Meanwhile, eco-efficiency is increasingly becoming a key requirement for success in business. The World Business Council for Sustainable Development (WBCSD 1992) describes eco-efficiency as a management strategy of doing more with less. In addition, Bustamante (2001) stated that eco-efficiency has gained significant recognition and importance because it promotes sustainable development by covering both economic and environmental dimensions of production. By doing so, it enables firms/organizations to look for environmental improvements on their practices at the same time that they are working towards increasing their profit. In practice, eco-efficiency is achieved through the pursuit of three core objectives: increasing product or service value; optimizing the use of resources; and, reducing environmental impact.

At the KILUS Multipurpose Cooperative (KILUS) in Ugong, Pasig, recycling of discarded tetra packs (both used and material rejects of the tetra pack manufacturers) is seen as a value-adding activity, and an environment-friendly one at that. The cooperative through its member-communities are able to produce durable and reusable handicrafts (e.g. bags, belts, wallets, plate mats, and others), that are not only beautiful but also serve definite purpose in human lives. This recycling activity encourages each individual as well as the institutions (government and private) to be more aware that wastes are not just mere wastes but raw materials for new products that could reduce the problem on waste disposal while providing livelihood for the community. Among the officers of KILUS and its members, these intentions are clear and are being pursued. However, it is a notable concern that while the technology for recycling of tetra packs is already available and designs are evolving in response to the changing tastes and preferences of the users, in reality and without those actually involved in the recycling knowing it, the process of recycling itself might be leaving environmental footprints that if known, can be remedied for sustainability promotion. In other words, there is also this possibility that KILUS is unknowingly, engaged in "dirty business." Dirty business, according to Sklyarova and Kobets (2011) is one of the criteria of "greenwashing." Greenwashing is defined as the act of misleading consumers regarding environmental benefits of a product or service. Considering this concept, for all its intents and purposes to protect the environment through recycling of used and factory-rejected tetra packs, the same activity might be harming the environment as well. Thus, it becomes imperative that the impacts to the environment of the value-adding activities or the operational performance and eco-efficiency of recycling them be determined.

The main objective of the study was to evaluate the operational performance and eco-efficiency of producing bags with used and factory-rejected tetra pack material as major input. It was hypothesized that bag production from both the used and rejected tetra pack material is operationally and eco-efficient throughout their production cycle.

CONCEPTUAL FRAMEWORK

Pongracz (2004) stated that waste management has three important components: recycling, re-use, and reduction of solid wastes. These so-called 3Rs are being used in the operational processes for the production of handicrafts from recycled tetra packs. Used and rejected tetra pack materials are subjected to several processes as they are transformed into another useful product, which in this case are different kinds and sizes of bags (Fig. 1). Given that there are two sources of raw materials, used or waste and those factory-rejected material, the process of production may differ although they may be some or all of the following: washing, drying, sorting, folding, weaving and sewing, and packaging. Depending on the main raw material used, the amount and value of other materials, energy, labor and other services rendered in various stages of production may vary. While new products (bags) are produced, additional costs are incurred, and new wastes are again generated. This goes to show that in the process of re-using or recycling, depending on the raw materials (used or factory-rejected), still wastes can be generated affecting eco-efficiency, that is, profitability and again the condition of the environment.

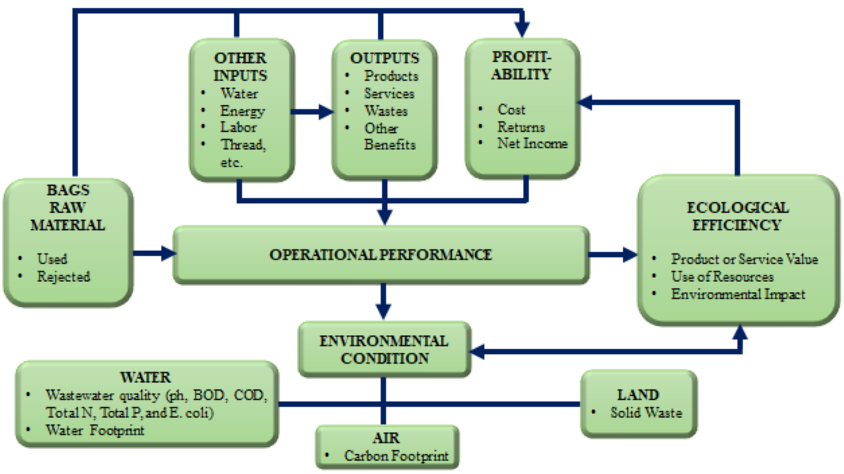

Fig. 1. Conceptual framework used in analyzing the operational performance of bag production from used and factory-rejected tetra packs.

Some indicators of the environmental condition are wastewater quality, solid waste generated, carbon, and water footprints. For water quality, pH, (biological oxygen demand (BOD), chemical oxygen demand (COD), Total N, Total P, E. coli (before and after washing the tetra packs), and water footprint are the parameters usually affected. For land, it is the amount of solid wastes generated and for air it is the carbon footprint.

RESEARCH METHODOLOGY

The study chose KILUS as the enterprise to analyze the performance in producing bags from used and rejected tetra pack raw material because it is the leading organization that engages in this type of production system in the Philippines. KILUS is based in Ugong, Pasig and a total of 81 (41% of the total active members of the cooperative) respondents were personally interviewed on the details of their production processes including wastes generation and management using pre-tested interview schedule. Administrative staff and worker-members were also interviewed.

Electricity consumption of bags production was determined, and corresponding costs were computed using the hourly rate (PhP5.17) prevalent at the time (2015). Carbon footprint expressed in kilogram carbon dioxide equivalent (Kg Co2eq) was likewise determined by taking the product of electricity consumed and the Philippines' carbon emission factor which was 0.4999 (IGES, 2009). In addition, water footprint which is the total volume of water (60 li) used in washing the discarded tetra packs (2,500 pieces) before proceeding to the bag-making process was also determined. During the production process, a total of 24 liters of waste water, at 6 liters per container (6 li for the control and 6 li each for the three rounds of washes) were collected. The samples were immediately brought to Lipa Quality Control Services in Lipa City, Batangas to determine the amount of biological oxygen demand (BOD), chemical oxygen demand (COD), *E. coli*, pH, Total Nitrogen and Total Phosphorus. Further, cost of BOD treatment using anaerobic digester was computed on the assumption that the retention time of the effluent is 30 days until BOD is reduced to 7 mg/li for Class C water and considering the Global Warming Standard for methane (CO2/CH4) of 21 and cost of $10/ton of carbon reduced (ADMU-Climate Change Information Center, 2003) at a rate of 1USD = PhP45.50).

Using the data generated from the laboratory tests performed for the control and the waste water from the three washes usually performed during the production process, values for a possible fourth wash were extrapolated.

RESULTS AND DISCUSSION

Handicraft (bag) production, based on the activities of KILUS consists of various stages: raw material collection/procurement, washing, drying, sorting, slashing/cutting, folding, weaving and sewing. At some stages in the production process, practices for the two different types of material (used and rejected tetra packs) differed so do their corresponding costs and wastes generated.

Step by step process of bag production from used tetra packs

KILUS is one of the organizations in Barangay Ugong in Pasig City with direct partnership for raw material collection with the Solid Waste Management Office (SWMO) under the supervision of the city government. Each barangay has a center leader appointed to collect/receive the used tetra packs from the households. The center leaders paid the households P0.20 for every tetra pack delivered straight to them. Before bag production, a sack of collected used packages (2,500 pieces) are washed three times in three separate five-gallon containers of water. Oftentimes, at first washing the washers used the water from their laundry to save water and detergent powder. Washing residues (or wash water) are poured out in canal that goes out to nearby creek. Washed tetra packs are hanged and dried for a few hours. Washers were paid P300 for every sack of washed tetra packs. Once dried, the sorter segregates by color and size. This process is essential for sewers as it eases their sewing thus helping them increase their daily output. Sewing is the final stage of handicraft production from used tetra packs (Fig. 2). Sewers are paid depending on the size and kind of the product produced.

Fig. 2. Steps in producing bags out of used tetra packs

Step-by-step process of bag production using factory-rejected tetra pack material

Rejected plasticized cardboard cartons are supposed to have been made into tetra packs but for some quality concerns have been found unfit for food grade use. They are however sold at P25/kg by the juice producing companies. Unlike used tetra packs, these are not washed but are instead rubbed-off with a piece of cloth dubbed with small amount of water and anti-bacterial fabric conditioner mixture to ensure that no dirt or dust is present. Using this material is more labor-intensive as it needs to be slashed/cut into strips of one and a half inches thick and eight feet long. Each roll weighs 5kg and produces 1,600 strips. During slashing, strips are categorized as either good (no noticeable scratch or uneven slashes) or completely rejected. This stage produces very minimal (about 5 gm per day) solid wastes. Some excess or rejected strips are used to fasten the folded strips for better organization of the work area.

The slashed or cut strips are then folded into four equal parts to make them thinner and more durable. This process pays the commissioned folders P20 per bundle (100 strips per bundle) who get the strips from the cooperative thrice a week and return them as folded strips after a week. No waste is generated at this stage. Folded strips are now ready for weaving, the last stage in the production process. Weaving entails interlacing the folded strips at right angles to each other (Fig. 3).

Operational performance

For comparability of the operational performances of the two raw materials in the production of bags, rolled tetra sheets were converted into equivalent amount of used tetra pack pieces. The equivalent amount of a strip from rejected tetra pack is 1.8 pcs of used/discarded tetra packs. Table 1 shows the amount of recycled and rejected tetra pack material used to produce bags (large, medium and small). The amount of tetra packs used varies with the size of the bags. More tetra packs were utilized in producing bags if rejected tetra pack materials were used. Rejected tetra packs were in strips form, while the recycled ones were processed in their original state. To produce a large woven bag, 200 strips are needed which is equivalent to 166 pieces of used tetra packs. Finished products for both raw materials have their respective markets. Sewed products made from recycled tetra packs were sold to local clients, in Manila and Boracay, Philippines. Majority of the woven products from rejected tetra pack material, however, were sold to international clients.

Fig. 3. Steps in producing bags out of rejeced tetra pack material

Table 1. Amount of used and rejected tetra packs used in producing different sizes of bag, KILUS Multipurpose Cooperative

Product	Used	Rejected
	Pieces	
Large	65	166
Medium	16	125
Small	10	83

Production cost

Cost is one of the many important factors to consider especially if a particular organization is engaged in production. Table 2 presents the comparative production cost of producing 100 bags (small, medium, and large) utilizing used and factory-rejected tetra packs. It should be noted that the cost of production using the rejected tetra pack material was higher than that from the used/discarded ones in all the three sizes of bags produced. The main reason is the fact that compared with weaving, sewing is less labor intensive. Utilizing used tetra packs, sewing had the largest share in cost ranging from 71 percent (for large) to 84 percent (for medium). Contributory to this also is the cost of lining material, usually a light-weight cloth, for improved durability and aesthetics. Similarly, the cost of weaving was the highest for bag production using factory-rejected tetra pack material ranging from 62 (large) to 74 percent (medium). In addition, the cost of folding the slashed strips had 18 to 21 percent share (Table 2). Folding is not done for used tetra packs.

Table 2. Cost of producing 100 bags, utilizing used and rejected tetra pack material, by size, KILUS Multipurpose Cooperative, 2015.

Bag size	Production stage	Cost of production			
		Used		Rejected	
		PhP	% Share	PhP	% Share
Small	Raw material collection/ Procurement	200	4	1,660	15
	Washing	605	12	-	-
	Cleaning	-	-	5	a
	Sorting	100	2	-	-
	Sewing	4,096	82	-	-
	Slashing	-	-	230	2
	Folding	-	-	2,000	18
	Weaving	-	-	7,000	64
	TOTAL	**5,001**	**101***	**10,895**	**99***
Medium	Raw material collection/ Procurement	320	4	-	-
	Washing	702	9	-	-
	Cleaning	-	-	61	a
	Sorting	200	3	-	-
	Sewing	6,222	84	-	-
	Slashing	-	-	350	2
	Folding	-	-	3,000	21
	Weaving	-	-	11,000	76
	TOTAL	**7,444**	**99***	**14,411**	**99***
Large	Raw material collection/ Procurement	1,300	11	3,320	16
	Washing	1,334	11	-	-
	Cleaning	-	-	76	a
	Sorting	800	6	-	-
	Sewing	8,782	71	-	-
	Slashing	-	-	460	2
	Folding	-	-	4,000	19
	Weaving	-	-	13,000	62
	TOTAL	**12,315**	**99***	**20,856**	**99***

a – less than one percent; * - did not add up to 100 due to rounding off

Cost and returns for bag using the recycled and rejected tetra packs

Table 3 presents the comparative costs and returns of producing 100 bags utilizing used and rejected tetra pack material. Production of woven products (from rejected tetra strips) generated a higher net income than the classic products (from used tetra packs). This was so because woven products had higher selling prices even though their costs were higher. A premium price can be charged for this product because people find them more attractive. In terms of quality, woven products are more durable because the strips used are longer and folded instead of pieced and sewn together as in used tetra packs. It is notable that the products made from the two raw materials catered to different markets. Classic products are for the low-end users while the woven products are intended for the high-end markets like tourists and the international market.

Table 3. Summary of the cost and returns of producing 100 bags by source of raw material and by size, KILUS Multipurpose Cooperative, 2015

Bag size	Used			Rejected		
	Gross return	**Cost of production**	**Net income**	**Gross return**	**Cost of production**	**Net income**
			PhP			
Small	11,000	5,001	**5,999**	35,000	10,895	**24,105**
Medium	12,000	7,444	**4,556**	40,000	16,911	**23,089**
Large	15,000	12,216	**2,784**	55,000	20,856	**34,144**

Environmental conditions and cost

Environmental condition is one of the most important considerations in environmental performance evaluation. It shows how the organization and its activities affect the environment. The environmental aspects considered are solid wastes generation, waste water and carbon and water footprints.

Solid Wastes. Table 4 shows the generation of wastes at every stage of bag production process for both used and rejected tetra packs. The amount of wastes generated from the used tetra packs was greater than the wastes produced when rejected materials were used. A total of 100 grams of solid wastes composed of small cuttings of tetra packs, threads, pieces of lining material and bag strap, were generated. In contrast, those from rejected materials produced only 60 grams of solid wastes per 100 bags. This small amount can be attributed to the fact that some of the trimmings from slashing and weaving are also being used as decorations and accessories to other products. Some are used as fasteners and decorations.

Table 4. Solid wastes generated in the production of 300 bags (100 bags per size).

Used		Rejected	
Stage	**Amount of waste (gm)**	**Stage**	**Amount of waste (gm)**
Raw material Collection	None	Raw material Collection	None
Washing	Wastewater	Cleaning	None
Drying	None	Slashing	30
Sorting	None	Folding	None
Sewing		Weaving	
Small	20	Small	10
Medium	30	Medium	10
Large	50	Large	10
Total	100	Total	60

The above findings are important because they established the fact that recycling tetra packs into bags can considerably reduce their presence in the landfills. It is important due mainly to the large volume of discarded tetra packs being thrown as wastes and have been collected by KILUS from within Barangay Ugong and nearby communities. For instance, in 2002, KILUS bought 3,100,000 pieces of tetra packs equivalent to 15.4 tons of garbage. A kilogram is about 200 pieces of tetra packs. From 2001 to 2009, about 96 tons of used/discarded tetra packs were collected and recycled and in 2012 and 2013, KILUS managed to collect a total of 50.9 tons of used and rejected tetra packs (Table 5) (KILUS, 2015).

Waste Water (Biological Oxygen Demand). Water is considered as one of the most important resources used in the recycling process for used tetra packs. It is therefore necessary to look at the pollutants present in the waste water to determine whether the recycling process has been harming the environment as well. Water quality is one of the indicators that need to be looked into. Based on the Department of Environment and Natural Resources (DENR) Administrative Orders No. 34 and 35, water classes have different water quality criteria based on the level of pollutants present (Table 6). It was observed that Class AA, or Public Water Supply Class I has the highest water quality criteria because it is supposed to be fit for drinking by humans. Class C on the other hand, can be fishery water for the propagation and growth of fish and other aquatic resources; recreational water for boating, and industrial water supply for manufacturing processes after treatment (DENR, 1990).

Table 5. Tetra pack collection of KILUS Multipurpose Cooperative in 2012 and 2013.

Month	Tetra packs collected (kg)			
	2012		2013	
	Used	Rejected	Used	Rejected
January	120.0	4,900	126.0	5,165
February	40.0	1,302	42.0	1,308
March	70.0	1,280	71.0	1,312
April	55.0	1,450	58.0	1,511
May	38.0	1,450	40.2	1,550
June	36.4	1,305	55.0	698
July	61.4	1,464	82.0	873
August	27.8	12,508	72.5	759
September	102.3	1,501	82.7	877
October	60.0	1,647	46.2	1,578
November	80.4	1,426	61.0	1,093
December	42.0	1,839	11.3	605
Total	**733.3**	**32,072**	**747.9**	**17,329**
Over-all	**32,805.3**		**18,077**	

Source: KILUS Foundation, Inc.

Table 6. Water quality criteria for conventional and other pollutants contributing to aesthetics and oxygen demand for fresh waters.

Parameter	Class AA	Class A	Class B	Class C
BOD,mg/L	1	5	5	7(10)
COD, mg O_2/L	300	60 – 100	60 – 100	100 – 150
E. coli, MPN/100ml	20	100	200	-
pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Total Nitrogen, mg/L	1	10	Nr	10[(j)]
Total Phosphorus, mg/L	Nil	0.1[(k)]	0.2[(k)]	0.4[(k)]

nil - extremely low concentration
(j) - Applicable only to lakes or reservoirs, and similarly impounded water
(k) - When applied to lakes or reservoirs, the Phosphate as P concentration should not exceed an average of 0.05 mg/L nor a maximum of 0.1 mg/L
Sources: DENR Administrative Order No. 34 and DENR Administrative Order No. 35

Results of the laboratory tests for sampled waste water revealed that after three washes, water quality improved considerably and was able to meet the standards for Class AA quality except for BOD requirement (Table 7). Also, the waste water quality from the first and second washes exceeded Class C standards, except again for BOD. The high BOD was due probably to the residual organic material in the tetra pack resulting from the juice's sugar residue which was removed during washing and is expectedly highest during the initial wash. This on the other hand, was drastically reduced in the second and third washes. Waste water from these is not fit even for irrigation or watering plants and therefore should not be released to the environment untreated. According to Soni and Mishra (2017), plants grown in the contaminated soils can amass toxic metal ions from the surroundings and their infiltration into the plant tissue can cause many health hazards.

Table 7. Amount of pollutants present in the laboratory-tested waste water samples

Parameter	Standard Criteria (AA)	Control	1st Wash	2nd Wash	3rd Wash	4th Wash*
BOD, mg/L	1	8	549	128	13	2
COD, mg O_2/L	300	10	668	137	22	<22
E. coli, MPN/100ml	20	<1.8	>16x10^3	7.8	<1.8	<1.8
pH	6.5 – 8.5	8.06	6.89	8.00	7.67	<7.67
Total nitrogen, mg/L	1	0.00	6.07	3.31	0.83	<0.83
Total phosphorus	Nil	0.05	0.74	0.69	0.18	<0.18

nil - extremely low concentration
*Projected based on the average reduction for the three previous washes

Carbon Footprint. Carbon footprint is defined a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product (Wiedmann and Minx, 2007). In this study, carbon footprint was derived from the electric consumption during the production of assorted sizes of bags and the corresponding methane from the BOD of the waste water (Table 8). Carbon footprint was only detected for bags whose raw materials were the used tetra packs.

There were two possible sources of carbon in the recycling process for used tetra packs: electricity consumption during sewing and methane emitted by the wastewater and measured through CO_2 equivalencies from the BOD. Global warming potential (GWP BOD (Kg Co_2Eq) of the use of electricity (14.997) in operating the sewing machine was found to be higher than the emission (methane) for the BOD (0.017) of collected waste water. As expected, large bags had the highest at 26.994 and 27.029, respectively (Table 8). In the absence of a definite standard per activity, these values were compared with the computed standard emissions from common household appliances like microwave oven and washing machine. In particular, a microwave oven in the household assumed to be used 96 times a year at 0.945 kilowatt-hour per use would generate carbon emissions amounting to 39 kg CO_2 Eq. per year. Similarly, a washing machine assumed to be used 187 times a year would yield 51 kg CO_2Eq. per year (carbonfootprint.com, undated). Comparing the emissions from KILUS bag production with that of the common household appliances, it is thus safe to say that the former is more environment-friendly, in all bag sizes.

Table 8. Carbon footprint of 100 bags produced by size from recycled tetra packs, KILUS, 2015

Bag size	Number of tetra packs used	GWP BOD (KgCO_2Eq.)		
		Use of electricity	BOD of wastewater	Total
Small	1000	8.998	0.006	9.004
Medium	1600	8.998	0.009	9.007
Large	6500	26.994	0.035	27.029
Average	3,033	14.997	0.017	15.013

Water Footprint. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business (Hoekstra et al, 2011). Table 9 shows the computed water footprint for 100 pieces of different bag sizes made from recycled tetra packs. They are noticeably low at three washes with only 218.4 li.

Table 9. Water footprint of producing 100 bags utilizing used tetra packs, by size.

Bag Size	Water footprint for 3 washes (li)	Water footprint for 4 washes (li)*	Difference (li)
Small	24.0	32.0	8.0
Medium	38.4	51.2	12.8
Large	156.0	208.0	52.0
Average	218.4	97.1	24.3

*Projected based on actual usage for the three previous washes

Despite its ability to reduce pollution possibility, still there are externalities incurred in the recycling process as evidenced by the greater than standard amount of BOD in waste water and positive global warming potential of sewing. For better appreciation, these externalities were converted into their peso costs. For BOD, the cost of cleaning the waste water to meet the standard was determined by computing how much it will cost to convert it hypothetically into the more economically important CO_4 or methane using anaerobic digester. Anaerobic digestion is actually composting without air as it breaks down microorganisms which are considered pollutants into simpler smaller compounds that are less harmful to the environment like methane (anaerobic-digestion.com, 2017). Methane has the second lowest global warming potential (ghgprotocol.org) relative to CO_2 and has more economical uses to households and small industries.

Table 10 shows that in producing 100 large bags, the cost to reduce the BOD to meet the standard criteria for Class C water would be PhP325 (PhP3.25/bag). It was almost negligible for small bags at PhP20/100 bags but still there is a chance that the process can further harm the environment, particularly water, when done at a large scale.

Table 10. Projected cost of BOD reduction to Class C water using anaerobic digester, 100 bags of different sizes

Bag size	Cost of BOD reduction (PhP)
Small	20
Medium	80
Large	325

Waste water treatment cost to capture CO_2 as usable methane was lower at PhP58.67 per 100 large bags and even lower at PhP11.23 per 100 units of small bags (Table 11).

Table 11. Projected cost of treatment of waste water generated from producing 100 bags of different sizes utilizing used tetra packs as raw material

Bag size	Cost of CO_2 emission from power generation (PhP)	Cost of waste water treatment	Total cost (PhP)
Small	4.09	7.14	11.23
Medium	4.09	11.43	15.52
Large	12.26	46.41	58.67

Eco-efficiency

Eco-efficiency is reached if KILUS was able to: increase product or service value; optimize the use of resources; and reduce environmental impacts. The primary raw materials which were already used and rejected tetra pack material could have been thrown in landfills or anywhere else to eventually cause pollution and contribute to environmental degradation. Recycling them into bags (and other handicrafts) means lessening the total amount of waste thrown away. They in fact became sources of income by members of KILUS and indirectly by other members of the community who were employed as workers and those who collected and sold the tetra packs to the cooperative. In this sense, the first criterion of being eco-efficient has been satisfied.

The Cooperative's recycling of tetra pack enabled it to reduce the waste generated. While the stages of the production process such as washing, slashing, weaving and sewing created wastes, the rejected strips used as fastener, and at times decorations led to the optimal use of resources or the raw materials. Release of methane into the air although highly possible is still quite minimal. However, in the instance that such will be experienced in large scale due to increased production, the same can be remedied by subjecting waste water to anaerobic digester treatment, the cost of which is quite low. In addition, Class C waste water can be used for watering ornamental plants also leading to water use optimization. More so, a better and still easily accomplished remedy is by performing another round of washing. It can be seen in Tables 7 and 9 that performing another round of washing (4^{th} wash) for the used tetra packs would reduce BOD to only 2 and leave water footprint amounting to an average of 97.1 li for 100 bags of different sizes or a maximum of 208 li for large bags and 32 li for small bags (total for four washes). This leaves a difference of an average of 24.3 li for all bag sizes (Table 9). Using recycled and rejected tetra packs as raw material and optimizing their use would lead to reduction in solid waste, hence, reduce the environmental impacts as well. Having met these objectives, it can be said that the tetra packs recycling is eco-efficient.

CONCLUSION AND RECOMMENDATIONS

Recycling of tetra packs both from used and rejected materials, is profitable and if properly implemented will leave very little negative environmental impacts if the used tetra packs will be washed for the fourth time before they are transformed into bags and other handicrafts. It is therefore recommended that KILUS should modify its process of washing used tetra packs by doing another round of washing instead of only three washes. It should also ensure that waste water from the first three washes are used only for watering ornamental plants and not food crops. It should also be safeguarded that the contaminated water does not reach a body of water without proper treatment for reduction of BOD. On the other hand, waste water from the fourth wash can be released to any body of water and even for watering food crops. As Sklyarova, and Kobets (2011) have put it "Companies can enhance their eco-efficiency through re-designing products, re-engineering processes, re-valorizing by-products and re-thinking markets. However, business cannot reach eco-efficiency objectives alone without governmental support and policy frameworks." It is therefore further recommended that the government, specifically the Ugong, Pasig local government, take active part in ensuring that the findings of this study are incorporated in the modified process of tetra packs recycling through an ordinance and its strict implementation, following the provisions of RA 9003. This recommendation is also consistent with what Sapuay (n.d.) concluded about RA 9003, "It contains tough provisions for waste segregation, collection, and disposal. It also outlines the necessary provisions to carry out collection and disposal of garbage in the most sanitary manner possible. It has also outlined the responsibilities of every agency responsible for every aspect of the law. However, the law seems to be prohibitive in that it penalizes those who do not obey but does not give ample rewards and incentives to those who comply." Overall, aside from strict implementation of the law, provision of incentives to those who are performing best practices will be a good strategy to ensure sustainability of "green" action.

ACKNOWLEDGEMENT

The funding support from the Department of Science and Technology of the Philippines is greatly appreciated along with the cooperation of the survey respondents, key informants, and the KILUS Multi-Purpose Cooperative of Ugong, Pasig for unselfishly providing the data needed for this study.

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