

Status and Challenges of Solid Waste Management in Beung Kiat Ngong Ramsar Site, Pathoumphone District, Champasack Province, Laos PDR

T. Khamkeo, S. Phaisansuthichol, P. Supapunt, and M. K. Pholchan

Abstract—Quantification and characterization of municipal solid waste are vital information for a proper solid waste management. However, these are under-investigated and scarcely implemented in Laos PDR, especially the local communities. This work, therefore, aimed to quantify and characterize municipal solid waste generated from Beung Kiat Ngong Ramsar Site and to recommend possible integrated solid waste management strategies for a sustainable waste management. The average daily waste generation was estimated to be 3.6 kg/day and 2.6 kg/day in Thabou village and Kiat Ngong village, respectively. Organic waste appeared to be the biggest component (28%) for Thabou village, while packaging's dominated waste composition in Kiat Ngong village. Interestingly, high percentage of golden apple shells waste were mismanaged. These had the potential to convert into value-added products such as calcium carbonate (CaCO_3). It was found that fresh golden apple shells contained only 24.16 ± 0.48 g/l as CaCO_3 , while incineration method increased higher CaCO_3 products. The result showed that incineration at the temperature of 400°C gave the highest amount of CaCO_3 with the values of 1207.67 ± 9.45 g/l as CaCO_3 . Based on the resources and the strength of the Ramsar site, the production of value added material from bio-waste could be integrated into waste management strategies along with 3Rs policies implementation.

Index Terms—Beung Kiat Ngong Ramsar site (BKN), solid waste management, golden apple snail shells (GAS), calcium carbonate (CaCO_3).

I. INTRODUCTION

Solid waste problems have recently gained a lot of concerns as it has increased in volume all over the world due to population expansion, continuous economic growth, urbanization and industrialization. Approximately, 2.01 billion tonnes of municipal solid waste has been annually generated around the world and 33% of that are mismanaged. Between 1980 and 2005 solid waste generation within the OECD countries has increased by as much as 2.5% per year. The numbers of total solid waste generation are likely to increase by a further 1.3% in 2030 and expected to grow to 3.40 billion tonnes by 2050.

The East Asia and Pacific region is generating most of the global waste (approximately 23 %). However, there is a positive correlation between waste generation and income

level. High-income countries are predicted to increase by 19 % by 2050, whereas middle and low-income countries are expected to increase by 40% or more [1].

In recent years, different solid waste management strategies and policies have been proposed and implemented in developing countries, including Lao PDR. However, achieving the goals and finding effective sustainable solutions for each area is one of the greatest challenges. This is because there are factors affecting waste management that are technical, financial, social-cultural, organizational, and legal-political barriers and population growth [2].

There are several strategies have been proposed. Appropriate identification, collection, separation, storage, transportation, treatment, and disposal, as well as important associated aspects including awareness and training, become part of effective solid waste management. Integrating solid waste management model have been successfully implemented in many countries. Different development goals, policies and frameworks focusing on reduce, reuse and recycling are acceptable practices [3]. Economic and financial benefits of waste recycling, waste to energy and value-added products from organic waste have also gained a lot of interests recently. In addition, a fairer system based on the polluter-pays principle for the businesses sector, environmental education and environmental awareness campaigns are important and also needed to drive long term achievement [4].

Converting waste to value-added products is one of strategies for waste management that has become popular in the recent year. Several studies have been done to produce calcium carbonate from golden apple snail and oyster shells and used as the reinforcing filler for poly vinyl chloride (PVC) [5]. Some works reported using golden apple snail shell as calcium supplement source for Japanese quail production. It was found that egg production has been increased while the operation cost was reduced [6]. Golden apple snail shells have been reported to be used as an organic filler for silicone rubber insulator. The results revealed that higher value of dielectric constant as well as higher dielectric strength were obtained [7].

Beung Kiat Ngong (BKN) Ramsar site in Pathoumphone district, Champasack province is one of two wetlands that has been designated as the Ramsar site. This preserved and precious natural habitat requires sustainable development policy. Up until now, however, solid waste management at BKN Ramsar site is still inefficient and needed to be improved. Moreover, it is expecting that higher amount of waste will be generated due to higher populations and visitors. In order to plan and propose a suitable strategy for

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better solid waste management in BKN Ramsar site, it is necessary to quantify and characterize waste generation and composition [8]. The golden apple snail shells (*Pomacea Caniculata*) grows and reproduces very rapidly as one snail can produce 1000-1200 eggs/ month with 80% hatchability [9]. Entrepreneurs have envisioned a profitable mass production of the golden apple snail shells as human food. This new exotic species has become a popular business among people living nearby Ramsar site. Apart from inefficient household and agricultural waste management, amount of shells has been developed with approximately 98,549 kg per year and still mismanaged. Therefore, the objectives of this study were to quantify and identify waste generation at BKN Ramsar site, Pathoumphone district, Champasack province, Laos PDR and propose the possible strategy for sustainable solid waste management, including golden apple snail shell. This study will be helpful to policymakers in designing a better and more efficient waste management systems.

II. MATERIALS AND METHODS

A. The Study Areas

The Beung Kiat Ngong Ramsar site (BKN) Ramsar site is located in Pathoumphone district, Champasack Province, Laos, PDR. It is about 56 km south of Pakse city and lies between $14^{\circ}43'02''$ S latitude and $104^{\circ}43'53''$ E longitude. (as shown in Fig. 1). It has approximately 2,360 hectares. BKN Ramsar site has eight villages where two villages that were Thahou village (agriculture area) and Kiat Ngong village (tourist site area) were selected in this study. The solid waste from landfills of both different areas were collected and mixed before sorting using quartering method [10]. This waste was then characterized. The percentage of each constituent and bulk density were then calculated as explained elsewhere. Moreover, secondary data regarding solid waste generation, collection system and disposal methods were collected from department of natural resources and environment in Champasack province.

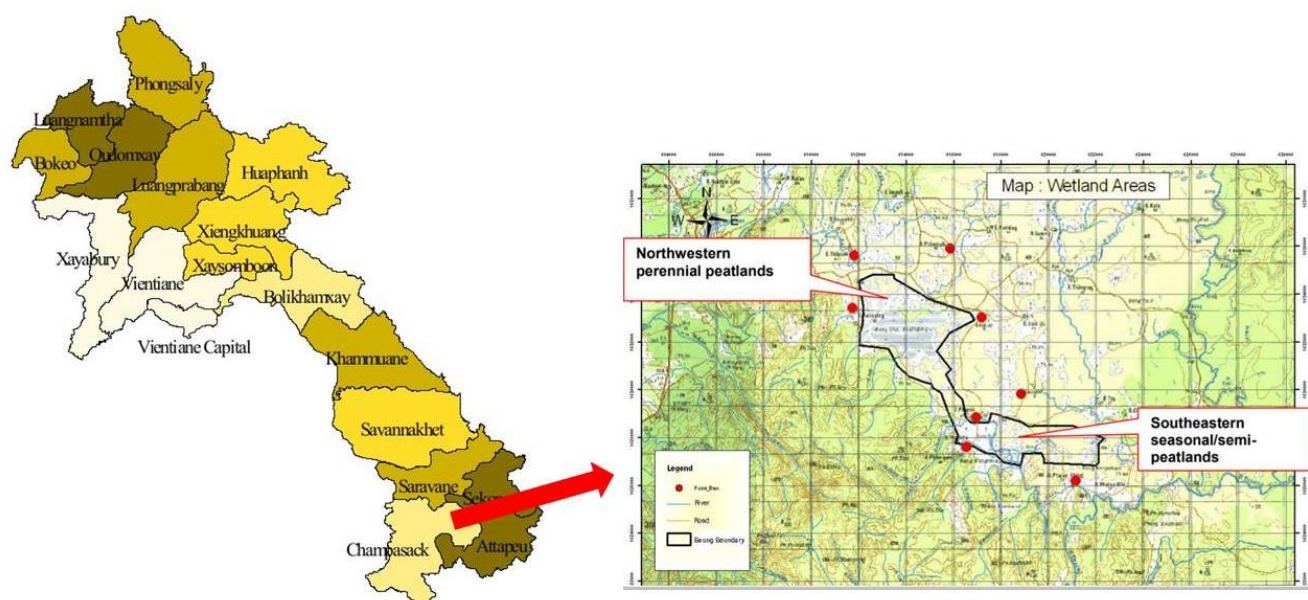


Fig. 1. Location of the study area (BKN, Laos PDR).

B. Experimental Set up for Obtaining CaCO_3 from Golden Apple Snail Shells (GAS)

Golden apple snail shells (GAS) were collected and approximately 2.7 kg of GAS were prepared by cleaning and air drying. Three treatments as shown from Fig.2 were conducted to find the best process for obtaining CaCO_3 from GAS. In treatment A, GAS was crushed into small pieces before incineration, while GAS from treatment B was burned directly without crushing. Treatment C was the control which was the fresh shells with no crushing and burning. GAS with triplicates were put into the incinerator for 1 hour with the temperatures varied at 400°C , 500°C and 600°C . The CaCO_3 obtained was then identified.

C. CaCO_3 Analysis

Calcium Carbonate (CaCO_3) contained in GAS samples from three treatments was analyzed using EDTA Titrimetric Method. 6M of HCl was added into 0.1g of GAS until it was

completely dissolved. It was then adjusted to 100 ml using acid solution before titrated with EDTA standard solution using murexide as an indicator (as explained elsewhere). The volume of EDTA used for titration (in milliliters) was multiplied by 20 to get the calcium Carbonate value in mg/L as CaCO_3 [11].

D. Statistical Data Analysis, SPSS

SPSS Anova was used to compare the statistically significant phase between experiments where CaCO_3 was obtained under different temperatures and different GAS preparation patterns. The size of the selected sample was calculated for a level of confidence of 95% with an error range of 5%.

III. RESULTS AND DISCUSSION

Based on the aforementioned analytical procedures the

following results have been found:

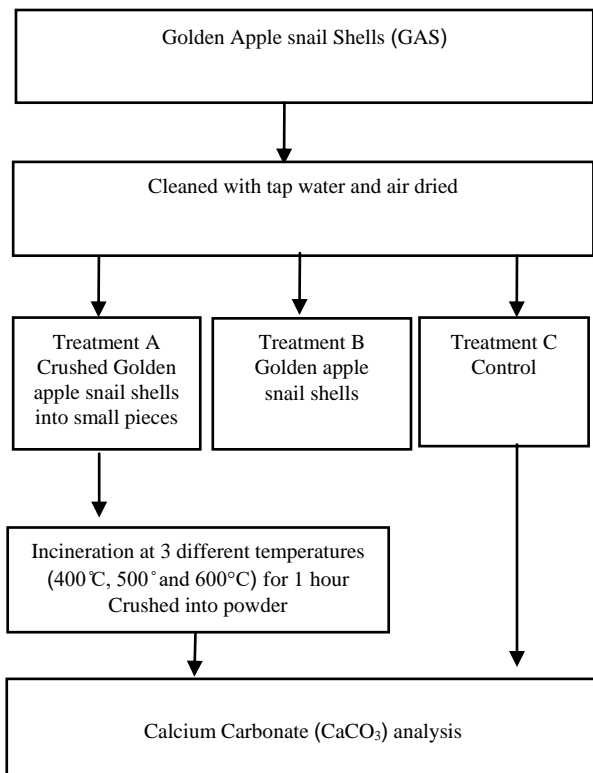


Fig. 2. Flow diagram of experimental design.

A. Waste Generation and Characteristics

BKN Ramsar site has provided enormous direct and indirect benefits for local communities. It was estimated in 2011 that the wetlands provided US\$ 897,607 of annual direct economic values. Besides, the information from department of information and tourism in Champasack province from 2013 to 2017 reported that the number of tourists has increased to 20,000 persons and tended to be rising. As a result, higher amount of solid waste has been generated in this areas.

Currently, Thahou village has 85 households with 224 populations, while Kiat Ngong village has 172 households with 431 populations in the community. The majority of the population are farmers who mainly engage in paddy rice cultivation and earn some extra income from tourism. The results indicated that only 10% of solid waste were dumped into the community landfill while 90% were golden apple snail shells that were open dumped everywhere in both areas.

During sampling in year 2020, it was found that Thahou village generated a daily average solid waste of 3.6 kg/day, while Kiat Ngong generated 2.3 kg/day. These numbers excluded food waste and agricultural waste which were used as raw materials for composting. It can be seen that the amounts of waste from both villages, which are local areas, are less than the one from the big city of Lao, PDR. This represents the low income and way of life in the local community. However, waste generation from both areas showed variation by locations, sources, and activities. In comparison with tourist site area in Thailand, it generates a low rate of approximately 0.3 kg/day. The differences could be either as a result of income level, economic and

consumption habit or disposal habits of people.

As seen from Fig. 3, organic waste forms the biggest component of solid waste generated in Thabou village which is about 28%. This is due to fallen leaves from trees or garden wastes and agriculture residues generated in this area. Normally, these wastes were managed by open burning. On the other hand, the lowest composition was found from paper, hazardous waste and milk can which is only 9% of total of solid waste. Most of the waste generated from Thabou village comes from nature due to it is an agricultural area which is far from markets. This is completely opposite to Kiat Ngong village where plastic dominated waste composition showing the largest proportion of 29%. It is also followed by milk can and foam which were 22% and 21% respectively. The major contributing factor of waste composition of this area is that it is the tourist destination where packaging has been used and generated with no or little recycling mechanisms.

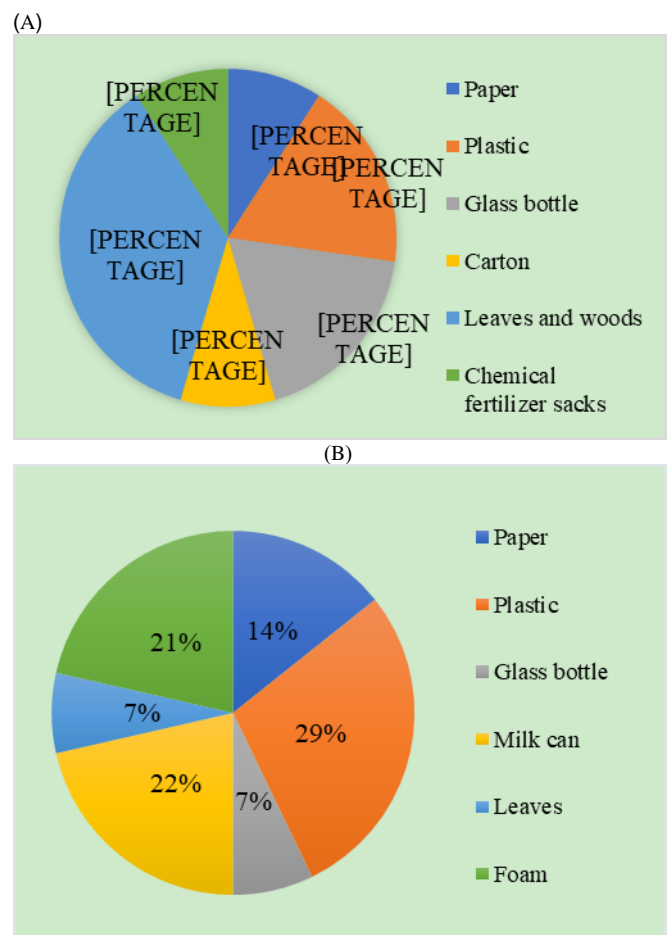


Fig. 3. Percentage waste composition in Thabou village (A) and in Kiat Ngong village (B).

Interestingly, large amount of golden apple snail shells was found from both villages which approximately 98,549 kg/ year. It appeared that this exotic species has become popular as high number of customers have increased. The income from selling golden apple snail shells in Pathoum phone market and DaoHeung market (in Pakse city) was as high as US\$287,000 per year (1 kg per 1 US\$) [3]. However, there is no disposal strategy, they were open dumped everywhere in these areas which seems to be a big environmental problem in the very near future.

B. CaCO_3 from GAS

In order to convert GAS into the value-added product, which is CaCO_3 , three different treatments were compared. It was found that there was a significant difference of the amount of calcium carbonate obtained between the control (fresh shells with no treatment) and shells after incineration ($P \geq 0.05$, ANOVA). Moreover, one-way ANOVA revealed statistically significant difference of calcium concentration between different burning temperature. It was found that fresh golden apple snail shells contained 24.16 ± 0.48 g/L as CaCO_3 . However, the method of burning GAS before

crushing into powder (treatment B) significantly increased the amount of calcium carbonate as shown in Fig 4. The result showed that higher temperature reduced the amount of calcium carbonate, while burning GAS at lowest temperature (400°C) gave highest amount of calcium carbonate with the value of 1207.67 ± 9.45 g/L as CaCO_3 and 304.92 ± 4.74 g/L as CaCO_3 for treatment B and A, respectively. Moreover, % yield obtained from both treatments (A and B) was found to be in the range of 93-96 % (Table I). Also, the result showed that treatment B with incineration temperature at 400°C gave highest % recovery with the value up to 96%.

TABLE I: GAS BIOMASS AND %YIELD OBTAINED FROM THREE TREATMENTS (A-CRUSHED BEFORE INCINERATED, B-INCINERATED WITHOUT CRUSHING AND C-CONTROL)

Treatments	Incineration temperature	Amount (mg)	Amount (mg)	% Yield
		Before incineration	After incineration	
A	400°C	201.48 ± 0.31	192.98 ± 1.03	95.7
	500°C	200.89 ± 0.46	192.49 ± 0.51	95.8
	600°C	200.58 ± 0.25	191.86 ± 0.21	95.7
B	400°C	201.08 ± 0.27	193.54 ± 0.41	96.2
	500°C	201.28 ± 0.49	190.12 ± 1.07	94.5
	600°C	201.93 ± 0.21	187.59 ± 4.88	92.9
C		198.52 ± 0.24		

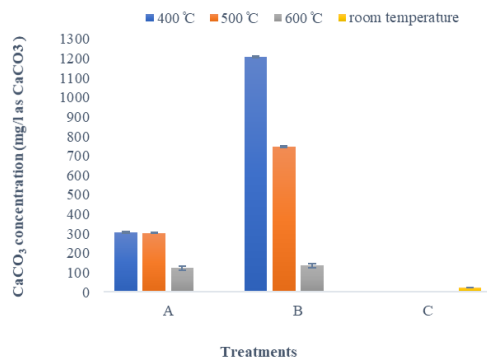


Fig. 4. Average concentration of CaCO_3 obtained from GAS between 3 treatments (A-crushed before incineration, B-incineration without crushing and C-control).

C. Recommendations for Driving Sustainable Solid Waste Management

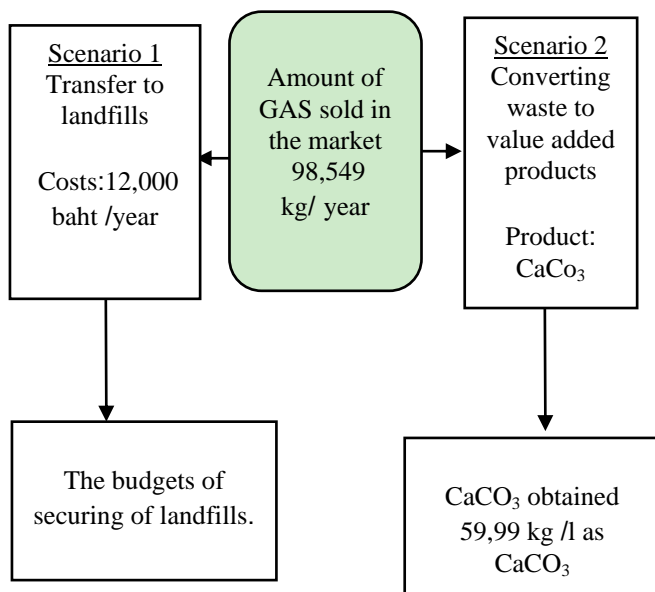


Fig. 5. Strategy of converting GAS into value CaCO_3 .

The characterization of solid waste in Ramsar area is the basis for sustainable solid waste management planning. Currently, the results showed that there is no separation at the source for compostable/organic waste from non-biodegradable wastes and everything have been dumped to the landfill. Also, the disposal practices of waste collecting, and management were not sustainable and open burning have been found. Based on the information obtained from above, a plan for strategies to prevent, reduce, separation, collect, recycle and value-added products becomes more effective for both areas as shown in Fig.5.to Fig.7.

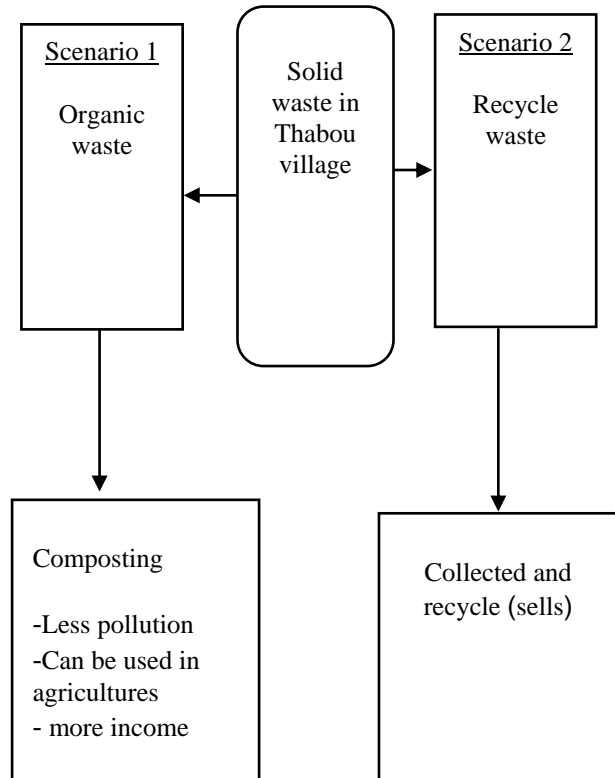


Fig. 6. Strategy of converting Solid waste into value at Thabou village.

In order to drive the improvement of solid waste management in the Ramsar site, it is important to develop zero waste policies and green strategies by encouraging reduction at the point of generation, implementing reuse and recycle programs for paper, plastics and other recyclable packaging, especially at the tourist destination area. Separate containers for different waste categories should be provided at the collection points. On the other hand, the application of composting for soil enrichment or feedstock for biogas production should be considered for organic waste management from the agriculture area.

Furthermore, converting waste into value added product is also one of the potential strategies for GAS management (Fig. 5). Every year GAS peels were generated in BKN Ramsar site as much as 98,549 kg / year. If there is no policy, the community will have to spend approximately 12,000 baht/ year for transferring these wastes to landfills which is quite costly for people living in this area considering that low GDP 2,534.9 \$ per year/person (GDP in 2019, Laos PDR) has been reported [12]. However, adding the values into GAS by converting into CaCO_3 , approximately 59.99 kg/L as CaCO_3 was produced as a replacement of CaCO_3 from bones or limestone. It can be used for many industrial production processes and agricultural sectors [8]. This can be an extra business and give more income for people in the Ramsar site area because the price of CaCO_3 powder (CaCO_3 from naturally Grade A) is around 107 baht/ 250 g [13]. Therefore, CaCO_3 produced from this amount of GAS generated could be around 80,468 baht.

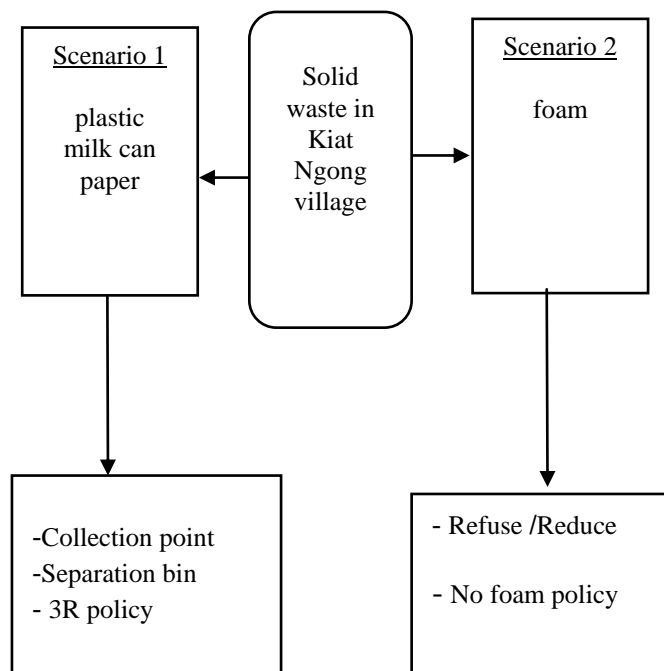


Fig. 7. Strategy of converting Solid waste into value at Kiat Ngong village.

IV. CONCLUSION

This work highlighted solid waste issues and management challenges in BKN, Pathoumphone district, Champasack province, Laos PDR. The result indicated that composition of waste varied between site and location, income and activities. It was also recommended that strategic policy framework and community awareness and involvement and participation are imperative for reduction, recycling, reuse, composting and

value-added production. If appropriate solid waste policies and technologies are introduced, people living in ramsar site can have better quality of life and more income while the natural ecosystem can be preserved.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Thiddavanh Khamkeo is studying at master's degree of environmental of technology in Maejo University, who performed the experiments, analyzed, interpreted the data, write a paper. Mujalin Pholchan is the corresponding author for this manuscript who advised, conceived, designed the experiments, and wrote and edited the manuscript. Sirirat Phaisansuthichol contributed chemical and analytical tools and supports while Patcharin supapunt contributed tools for economic worthiness analysis.

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