COMMUNITY BASED SOLID WASTE MANAGEMENT AT BEUNG KIAT NGONG RAMSAR SITE IN LAOS PDR.

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MASTER OF SCIENCE IN ENVIRONMENTAL TECHNOLOGY

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT
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ชื่อเรื่อง การจัดการขยะชุมชนในพื้นที่บึงเขียดโง่ง อำเภอปทุมพร จังหวัดจำปาสัก ประเทศสาธารณรัฐประชาธิปไตยประชาชนลาว
ชื่อผู้เขียน Miss Thiddavanh Khamkeo
ชื่อปริญญา วิทยาศาสตรมหาบัณฑิต สาขาวิชาเทคโนโลยีสิ่งแวดล้อม
อาจารย์ที่ปรึกษาหลัก อาจารย์ ดร.มุจลินทร์ ผลจันทร์

บทคัดย่อ

ปริมาณและลักษณะเฉพาะของขยะชุมชนเป็นข้อมูลสำคัญสำหรับการจัดการขยะชุมชนที่เหมาะสม ซึ่งข้อมูลเหล่านี้ยังมีการศึกษาน้อยมากและไม่ได้มีการนำมาใช้ใน สปป. ลาว มากนัก โดยเฉพาะในพื้นที่ชุ่มน้ำ เพื่อปฏิบัติตามนโยบายและเป้าหมายการพัฒนาอย่างยั่งยืนของรัฐบาล สปป. ลาว ที่มีเป้าหมายในการพัฒนาประเทศให้หลุดพ้นจากความทุกข์ยาก พร้อมกับการพัฒนาแบบยั่งยืน โดยเฉพาะการลดปัญหาทางด้านสิ่งแวดล้อม เรื่องการแก้ปัญหาทางด้านขยะชุมชน หนึ่งในพื้นที่เป้าหมายในการพัฒนาแบบยั่งยืนนั้น คือ บึงเขียดโง้งแรมซาร์ อำเภอประทุมพอน จังหวัดจำปาสัก สปป. ลาว ซึ่งเป็นพื้นที่ชุ่มน้ำที่มีความสำคัญ ทั้งในด้านที่อยู่อาศัยของสัตว์นานาชนิด และเป็นพื้นที่ยุทธศาสตร์ของ สปป. ลาว เป็นพื้นที่เป้าหมายในการพัฒนาแบบยั่งยืน โดยเฉพาะทางด้านการจัดการขยะชุมชน ซึ่งงานวิจัยนี้มี 2 วัตถุประสงค์คือ 1. เพื่อหาปริมาณและลักษณะของขยะชุมชนที่เกิดขึ้นในพื้นที่บึงเขียดโง้งแรมซาร์ สปป. ลาว และ 2. เสนอแนะกลยุทธ์การจัดการขยะชุมชนอย่างยั่งยืน ซึ่งงานวิจัยได้แบ่งออกเป็น 3 ส่วน ได้แก่ ส่วนที่ 1 การลงสำรวจพื้นที่และเก็บตัวอย่างเพื่อหาปริมาณขยะชุมชน องค์ประกอบ ประเภทของขยะชุมชน และความหนาแน่นของขยะชุมชน ส่วนที่ 2 สำรวจความคิดเห็นโดยใช้แบบสอบถามชาวบ้านในพื้นที่และพนักงานจากแผนกทรัพยากรธรรมชาติและสิ่งแวดล้อม จังหวัดจำปาสัก สปป. ลาว ที่รับผิดชอบในการกำหนดนโยบายและดำเนินงาน และส่วนที่ 3 การศึกษาการเพิ่มมูลค่าจากขยะในระดับห้องปฏิบัติการ

ผลการศึกษาส่วนที่ 1 จากการสำรวจพื้นที่ทั้ง 2 หมู่บ้านที่เป็นตัวแทนของพื้นที่บึงเขียดโง้งแรมซาร์ พบว่าหมู่บ้านพระโพและหมู่บ้านเขียดโง้งมีการสร้างขยะชุมชนเฉลี่ย 3.6 ก.ก./วัน และ 2.6 ก.ก./วัน ตามลำดับ ประเภทขยะที่พบมากที่สุด คือ ขยะอินทรีย์ 36.4% และบรรจุภัณฑ์ 28.6% ตามลำดับ นอกจากนี้ทั้ง 2 หมู่บ้านมีการทิ้งขยะแบบเทกอง เผาที่โล่งแจ้ง และหลุมฝังกลบขยะไม่ได้มาตรฐาน และพบว่ามีขยะจากเปลือกหอยเชอรี่มากที่สุดถึง 90% ของขยะทั้งหมดที่ถูกทิ้งอยู่ตามพื้นที่สาธารณะ

ผลการศึกษาส่วนที่ 2 จากแบบสอบถามสามารถสรุปได้ว่า ทั้ง 2 หมู่บ้านขาดความรู้ความเข้าใจในการคัดแยกขยะตามหลัก 3Rs เมื่อเปรียบเทียบส่วนทัศนคติและพฤติกรรมการจัดการขยะชุมชนระหว่างหมู่บ้านพระโพและหมู่บ้านเขียดโง้ง พบว่าหมู่บ้านพระโพมีทัศนคติและพฤติกรรมที่ดีกว่าเกี่ยวกับการจัดการขยะด้วยการคัดแยกขยะตามหลัก 3Rs และนอกจากนี้ผลจากแบบสอบถามจากส่วนพนักงานแผนกทรัพยากรธรรมชาติ และสิ่งแวดล้อม จังหวัดจำปาสัก สปป. ลาว ที่รับผิดชอบในการกำหนดนโยบายและดำเนินงาน พบว่ามีความรู้ความเข้าใจในการคัดแยกขยะตามหลัก 3Rs และมีประสบการณ์ในการทำงานเกี่ยวกับการจัดการขยะแต่ยังขาดความรู้ความเข้าใจในการนำขยะมาเปลี่ยนเป็นพลังงานและการเพิ่มมูลค่าขยะ

ผลการศึกษาส่วนที่ 3 การศึกษาการเพิ่มมูลค่าจากขยะในระดับห้องปฏิบัติการ เนื่องจากผลของการลงสำรวจพื้นที่บึงเขียดโง้งแรมซาร์ไซ พบว่ามีขยะจากเปลือกหอยเชอรี่มากที่สุดถึง 90% ของขยะทั้งหมดที่ถูกทิ้งอยู่ตามพื้นที่สาธารณะ เปลือกหอยเหล่านี้มีส่วนประกอบแคลเซียมคาร์บอเนต ($CaCO_3$) ซึ่งสามารถนำมา สร้างมูลค่าเพิ่มได้ จึงได้มีการทดลองเผาเปลือกหอย เพื่อเปรียบเทียบระหว่างอุณหภูมิที่เผา 400°C 500°C และ 600°C และการเตรียมเปลือกหอยก่อนนำไปเผา โดยแบ่งเป็นการทุบเปลือกหอย (Treatment A) ไม่ได้ทุบเปลือกหอย (Treatment B) และเปลือกหอยบดแต่ไม่ได้ทำการเผา (Control) จากนั้นทำการหาปริมาณ $CaCO_3$ ด้วยวิธี EDTA และ AAS พบว่าเปลือกหอยที่ไม่ได้ทุบก่อนเผาที่อุณหภูมิ 400°C ให้ปริมาณ $CaCO_3$ มากที่สุดและแตกต่างจากชุดการทดลองอื่นอย่างมีนัยสำคัญทางสถิติ (ANOVA; P=0.006) โดยมีค่าสูงสุดเมื่อใช้การวัดด้วยวิธี EDTA 624.00 เท่ากับ mg/L as $CaCO_3$ และ AAS เท่ากับ 64.65 mg/L as $CaCO_3$ ผลการศึกษาแสดงให้เห็นว่าการ เพิ่มมูลค่าจากเปลือกหอยเชอรี่ให้กลายเป็น $CaCO_3$ สามารถนำไปประยุกต์ใช้ในอุตสาหกรรม และการเกษตรเป็นการเพิ่มมูลค่าให้แก่ขยะชุมชน นอกจากนี้ควรมีการเพิ่มความรู้ความเข้าใจเกี่ยวกับการจัดการขยะชุมชน โดยเฉพาะด้านการคัดแยกขยะตามประเภทของขยะ และหลัก 3Rs รวมไปถึง การสร้างมูลค่าเพิ่มให้แก่ขยะชุมชน การฝึกอบรม เรื่องการเปลี่ยนของเสียให้เป็นพลังงาน การทำปุ๋ยหมักจากขยะอินทรีย์ ให้แก่ชุมชนในพื้นที่บึงเขียดโง้งแรมซาร์ไซ สปป. ลาว เพื่อการจัดการขยะชุมชนอย่างยั่งยืนในพื้นที่ดังกล่าว

คำสำคัญ : บึงเขียดโง้งรามซาไซ, การจัดการขยะชุมชน, เปลือกหอยเชอรี่, calcium carbonate

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Title	COMMUNITY BASED SOLID WASTE MANAGEMENTAT BEUNG KIAT NGONG RAMSAR SITE IN LAOS PDR.
Author	Miss Thiddavanh Khamkeo
Degree	Master of Science in Environmental Technology
Advisory Committee Chairperson	Dr. Mujalin Pholchan

ABSTRACT

The quantity and characteristics of solid waste are essential information for appropriate solid waste management. These data are still lacking and are not widely used in Lao PDR, especially in wetlands areas. To comply with the sustainable development policy and sustainable goals, Lao PDR government aims for the development of the country from poverty along with sustainable development. It also targets for solving environmental problems as well as solid waste problems. BKN Ramsar site is the habitats of various animal habitats and a strategic area of the Lao PDR which is the target area for sustainable development. The objectives of the study were 1. to analyze and characterize the amount and composition of solid waste and, 2. to find strategic solid waste management in Beung Kiat Ngong Ramsar site, Pathoumphone district, Champasack Province, Laos PDR. The research was divided into 3 parts: Part 1. Survey and waste sampling to identify the amount of solid waste, characterization and composition of solid waste and, the density of solid waste. Part 2 .The distribution of questionnaire targeted on villagers in the area and staffs from the department of natural resources and environment, Champasak Province, Lao PDR who responsible for policy-making and implementation, and part 3. Preliminary laboratory study of value added product from waste.

The results from part 1 after survey and sampling solid waste from two villages in BKN Ramsar site; Thabou village and Kait Ngong village showed that the average daily solid waste generation 3.6 kg/day and 2.6 kg/day in Thabou village and Kiat Ngong village, respectively. Yard waste appeared to be the biggest component

(36.4%) for Thabou village, while packaging's dominated waste composition in Kiat Ngong village (28.6%). Open burning and open dumping in public areas and villages' landfills were general waste management process from both villages. Large amount of golden apple snail shells (GAS) was found with nearly 90% of the total solid waste and were dumped in public areas and villages' landfills.

The result from part 2 showed the responses from villages and DNRE. Lacking of knowledge and understanding of solid waste separation and 3Rs were found from both villages. When comparing the attitude and behavior of solid waste management between Thabou village and Kiat Ngong Village, it was found that Thabou village had more better attitudes and behaviors regarding solid waste management by solid waste separation and 3Rs. It was found that DNRE staffs had more knowledge and understanding on solid waste management and all staffs had the great attitudes towards solid waste management. However, more knowledge and professional training for waste to energy and waste to value added products are required.

The results of preliminary study from part 3 showed that golden apple snail shells (GAS), which were found nearly 90% of the total solid waste dumped in public areas, was selected as the raw material for value added production. These GAS contained calcium carbonate ($CaCO_3$), which can be used for industrial and agricultural purpose.Incineration was used for organic removal. Comparative test between three combustion temperatures; 400°C, 500°C and 600°C and 3 treatments (crushed before incineration (Treatment A), incineration without crushing (Treatment B) and control (C)) was conducted. $CaCO_3$ was determined by EDTA method and AAS method. It was found that Treatment B (400°C) gave the maximum value of $CaCO_3$ (624.00 mg/L as $CaCO_3$ from EDAT method and 64.65 mg/L as $CaCO_3$ from AAS method), which was significantly different between others (ANOVA; P=0.006). The findings indicated that the value added product from GAS to $CaCO_3$ could be applied in the industry and agriculture. Moreover, strategy plans on education and knowledge related to waste management, waste separation and 3Rs, waste to value added

products and training on waste to energy and composting should be conducted and developed for sustainable solid waste management in BKN Ramsar site.

Keywords : Beung Kiat Ngong Ramsar Site, solid waste management, golden apple snail shells, calcium carbonate

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Thiddavanh Khamkeo

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CHAPTER 1

INTRODUCTION

1.Background

Municipal solid waste (MSW) rapidly increased in recent years and its treatment and management poses a huge challenge to local authorities in countries over the world, including Laos PDR. Simple dumping, open burning and local landfill pose hidden dangers to soil, water and air quality. In order to solve these environmental problems, the government has been trying to develop green policy and activity plans for environmental protection such as acceleration of the nation development, and sustainable development to guarantee continually economic expansion along with the better quality of life (MPI, 2016). This includes the policy and strategy plan for solid waste management.

Solid waste in Champasack province, Laos PDR is also one of major environmental problems. According to the report of the urban development and management office in Champasack Province in 2018, it was found that the amount of waste produced in Champasack province was 0.7 kg/capital/day. However, only 40 to 50 tons/day were transferred to the landfills which were 17 km far from Pakse. The area of each landfill is 1.5 km^2 and they are not sanitary landfills as there are no lining materials and leachate systems. Up until now, there is no such strategies to collect, transfer, dispose and manage waste from its sources to landfills. Lacking of policy and regulations, financial support, facilities, awareness and education affect the success of solid waste management in the community.

Beung Kiat Ngong Ramsar site in Pathoumphone district, Champasack province is one of places that requires sustainable development policy because it consists of a number of important wetlands and precious natural habitats. There are nearly 11,500 people from eight villages living in this Ramsar site and rely on agriculture, wildlife capture, wild vegetables and non- wood forest products and extra income from tourisms. In recent years, there are no solid waste management strategies and policies being proposed and implemented in Beung Kiat Ngong Ramsar site. Achieving the sustainable goals and finding effective waste management solutions in this area is

one of the greatest challenges. There are factors affecting waste management and its applications such as techniques, financial support, social and culture, organization, and legal-political barriers and population growth (Nachalida, 2017). There are several strategies have been proposed such as appropriate identification, collection, separation, storage, transportation, treatment, 3Rs (reduce, reuse and recycling), waste to energy, waste to value-added products and disposal (Runpin, 2011); (Challcharoenwattana, 2015) and (S.Petchpankan, 2 0 1 9). Integrated waste management has been accepted as a sustainable approach for solid waste management and has been successfully implemented in both developed and developing countries. The difference among places is the approach taken to develop the integrated waste management system. Integrated waste management system offers the flexibility of waste treatment option based on different waste fraction like plastic, glass, organic waste or combustible waste. Energy and resource recovery is also important and can be recovered through integrated waste management system. In addition, the associated aspects including awareness and training are important part of effective solid waste management that should be concerned. In addition, a fairer system based on the polluter-pays principle for the businesses sector, environmental education and environmental awareness campaigns are important and needed to drive long term achievement (Y.Suma, 2019).

The aims of this study were to propose the possible strategy for sustainable solid waste management in BKN Ramsar site, Pathoumphone district, Champasack province, Laos PDR. Two villages; Thahou village and Kiat Ngong village were selected as the representative model of agricultural area and tourism attraction. In order to plan and propose a suitable strategy for better solid waste management in BKN Ramsar site, it is necessary to quantify, identify and characterize waste generation and waste composition from the current situation. Opinions, awareness and attitudes towards waste management from communities and authorities were also gathered using questionnaires. Secondary data of recent solid waste information from the department of natural resources, international union for conservation of nature (IUCN) was collected. Moreover, the preliminary study of converting waste to value added products was studied and economic evaluation of each strategy was

determined. The findings of this study would hopefully be helpful for the policymakers to design a better and more efficient waste management systems.

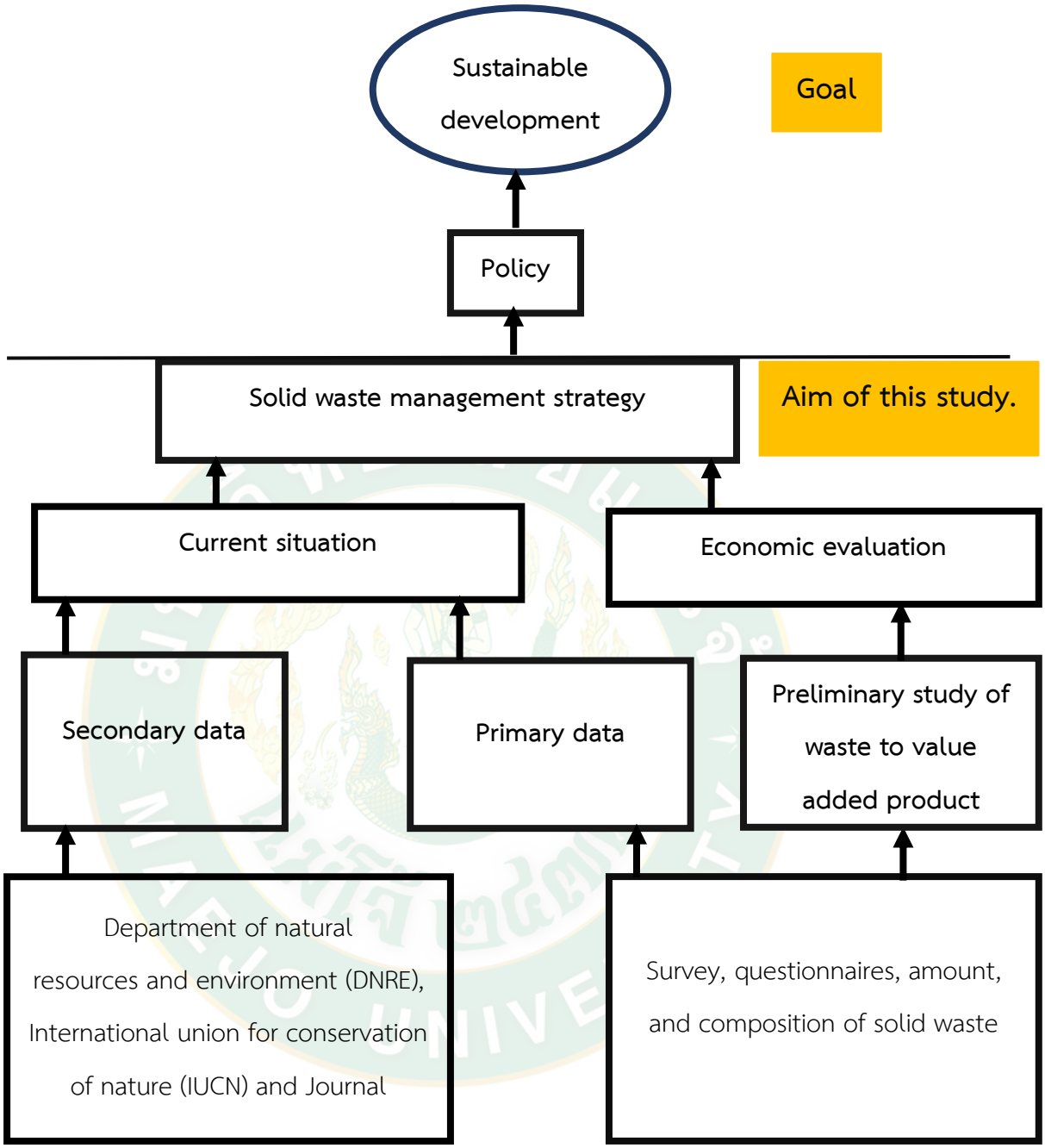


Figure 1 The schematic diagram of study.

2. Objectives of the study

2.1 To analyze and characterize the amount and composition of solid waste in Beung Kiat Ngong Ramsar site, Pathoumphone district, Champasack Province, Laos PDR.

2.2 To propose solid waste management strategic for Beung Kiat Ngong Ramsar site, Pathoumphone district, Champasack Province, Laos PDR.

3. Expected results

3.1 The possible solid waste management strategic for sustainable community development.

3.2 The information of current amount and composition of waste from two selected villages.

3.3 The preliminary result of value- added product development from solid waste.

3.4 Opinions, awareness, behavior and education background of communities toward solid waste management.

4. Scope and limitation

4.1 The study area

Two out of eight villages in Beung Kiat Ngong Ramsar site, Thahou Village and Kiat Ngong Village were selected as below:

1) Thahou village

There are 85 households with 224 populations. This area represents the agricultural village model.

2) Kiat Ngong village

There are 172 households with 431populations. This area represents the tourism business village model.

4.2 Data collection

The data collection of this study comprising of community characteristics and municipal solid waste sampling and community characteristics, both primary, secondary data investigated and information from laboratory. Questionnaires were used for primary data collection from two target areas, while regarding wastes separation and, community waste management.

CHAPTER 2

LITERATURE REVIEW

This research targets on the study of community based solid waste management at Beung Kiat Ngong Ramsar site, Pathoumphone district, Champasack province, Laos PDR. The researcher has reviewed the background information, ideas, theories and recent works related to solid waste managements as follows:

1. Physical characteristics
2. Social features
3. Economic characteristics in general and occupation
4. Tourism and recreation
5. Solid waste management
6. Integrated waste management
7. Sustainable development
8. Related research

1. Physical characteristics

1.1 Territory and terrain

The Bung Kiat Ngong wetland has 2,360 hectares and has located in Pathoumphone district, Champasak Province, which is 56 km in the south of Pakse city, Champasack province. It is 120 to 200 meters high above sea level. The southern parts of the wetland was located within the XePian National Protected Area (NPA). It is included in the Indo-Burma biodiversity hotspot or the central indochina area (tropical lowland plain) (IUCN, 2012).

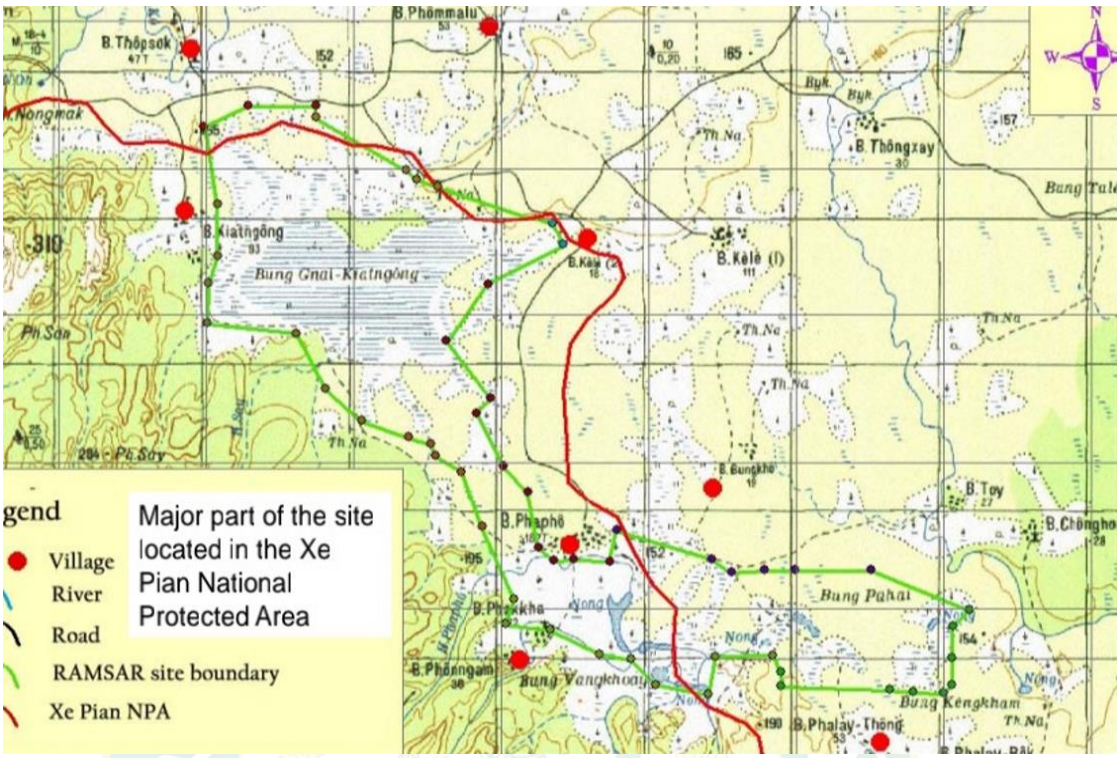


Figure 2 The wetlands and main villages

The northern part of wetland (14° 47’ 06”-106° 02’10” to 14° 46’ 18”- 106° 05’ 12”) is along the route no.18A (the road goes to Thangbeng village at Km 48 of Pathoumphone district, Champasak Province, to Sanamxay district of Attapeu Province). The edge follows from Topsok village to the junction with the road to Phapho village. The boundary curves around the road running through Kelae Noi village then connects to Phapho village at the eastern border. The southern border is between 14° 43’ 02”/106° 04’ 37” and 14° 42’ 19”/106° 08’ 26” which lies along the forest of Xe Pian (NPA) from Phapho village to Kiat Ngong village, and the western border starts from Kiat Ngong village (approximately 500 meters) before reaching Topsok village (14° 46’ 16”/106° 02’ 16”).

Coordinates:

Most northerly point: 14°47’29” N, 106°02’21” E (Topsok village, Route 18 A)

Most southerly point: 14°42’01” N, 106°08’30” E (Phalaybok village, forest of Xe Pian)

Most easterly point: 14°43’53” N, 106°08’42” E (Chong Houay)

Most westerly point: 14°46’16” N, 106°02’16” E (IUCN, 2012)

1.2 The weather

Beung Kiat Ngong wetland is in the monsoon season. The dry season starts from late October to early May and rainy season begins from late May to October. The lowest temperature is 14.5 degrees Celsius in January with the humidity of 32% to 95%. It can reach to a maximum of 38.3 degrees Celsius in April with the humidity of 39% to 96%. However, the humidity is near 99% throughout the rainy season. The average rainfall is about 2,000 mm per year. The climate change has the impact on changes in temperature, amount of rain, and wind velocities in lower Mekong river basin which also has the effect on Beung Kiat Ngong wetland in terms of changing of natural ecosystem and agriculture and food production (IUCN, 2012).

2. Social features

Beung Kiat Ngong has approximately 11,500 people from eight villages. The majority of the population were farmers who mainly engage in paddy rice cultivation and earn extra income from tourism. The people of the Beung Kiat Ngong area are almighty Lao Loum, the largest ethnic group in Lao PDR (they are three ethnic groups Lao Loum, Youane and Brao). In the past, there has been a correlation between the indigenous Mon-Khmer groups in the region, but they have now become Lao. Some of these villages have been there for centuries, while others were established recently as new people moved into areas (IUCN, 2012).

3. Economic characteristics in general and occupation

The Beung Kiat Ngong wetlands 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 value. There were 350 elephants, buffalo, and cattle that were up to 5,430 “grazing units” which consume almost 40,000 tons of wetland vegetation. The income from selling golden apple snail shells *(Pomacea Canaliculata)* (PC) in Pathoumphone market and DaoHeung market (in Pakse city) were about US$287,000 (1 kg per US$1). The income from elephant trekking has been placed to more than US$20,000 per year. This brought the net economic value of the wetlands closer to US$1,132,000 annually (IUCN, 2012).

4. Tourism and recreation

Beung Kiat Ngong wetlands and Phou Asa are among the most well-known tourist sites in Champasack province apart from the Khonepaphet water fall and Wat Phou temple. Phou Asa mountain provides a view of the green wetlands and forest, as well as the archaeological site on the mountain. The number of domestic and foreign tourists visiting Champassack province has increased steadily over recent years. In 2014, they were 318,760 visitors and the numbers has increased to 479,838 in 2017(tourism, 2018). Approximately 10,000 tourists per year visited Pathoumphone district and stopped at Kiat Nong village, Phou Asa and surrounding areas. According to the Pathoumphone district tourism office, the number of visitors has increased to 46% with more 4,896 people visiting in 2017. Elephant trekking has a significant revenue generator for local mahouts with the income as high as US$ 23,000. Since tourism has expanded in Kiat Ngong ramsar site, there are great opportunities to expand their elephant riding service, as well as to participate in guiding tours, to operate guesthouses and home stay services, and to sell handicrafts and other local products.

5. Solid waste management

5.1 Solid waste

5.1.1 Definition of solid waste

Solid waste means things that are used in human life activities and are discarded because they are no longer available or used and become something that has no value or not useful for life. These includes paper waste, cloth, food scraps, packaging products, plastic bags, food containers, ash, animal feces and other things that come from households, roads, markets, animal shelters or other places. The solid waste also include infectious waste, toxic waste from communities or households except for the unused materials from the factory which has special characteristics and properties (Kanti, 2000).

5.1.2 Types of solid waste

There are four types of solid waste that are compostable waste, recycle waste, hazardous waste and general waste which are explained below.

1. Compostable waste is the waste that can be rotten. It can be decomposed quickly and can be composted into compost, such as vegetable scraps, fruit, food scraps, leaves, meat scraps etc. This degradable waste is the highest waste proportion, which is found to be 60 percent of the total waste.

2. Recyclable waste is waste packaging or waste materials that can be recycled such as glass, paper, plastic scraps, beverage cans, metal scraps, iron, aluminum, used tires, etc. Approximately 30% of the recycle waste can be found from the total waste.

3. Hazardous waste is solid waste that is contaminated with various types of hazardous substances; including explosives, flammable substances, oxidizing materials, toxic substances, toxic substances, corrosive substances, irritating materials, or others that may cause danger to human beings, animals, plants, property and the environment such as batteries and electronic waste.

4. General waste is the waste that is not compostable waste, recyclable waste and hazardous waste. They are difficult to degrade and are not worth to reuse or recycle. For example; plastic wraps, candy wrappers, plastic bags, containers, foam, tissue paper, etc.

5.2 Solid waste management (SWM)

5.2.1 Definition of solid waste management

Solid waste management (SWM) refers to the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste in urban areas (Schubeler, 1996). Waste are collected from households, non-hazardous solid waste from industrial, commercial, institutions, market, yard waste and street sweepings. Semi solid waste such as sludge and soil are responsible by wastewater management systems. Hazardous, industrial and medical waste are not components of solid waste and they are often quite difficult to separate from solid waste, particularly when their sources are small and scattered. SWM is one of the main responsibilities and services of city government or municipality to provide for their residents (Hoornweg and Bhada-Tata, 2012).

5.2.2 Sanitary Landfill

Solid waste disposal and management by landfill method is the process of collection and waste transfer to prepared area. The sanitary landfill is designed to prevent environmental problems due to biodegradation process such as leachate, odor, gases and insect vectors. Machines are used to spread, compact and cover the waste pile with soil. In terms of landfill operations, it requires a standard design of the appropriate engineering structure for lining, wastewater treatment, gas discharge from landfill area and monitoring the leakage of leachate. The area should be vast enough and far away from the community. There are three types of sanitary landfill as explained below:

Area Method

This landfill method starts from compaction of solid waste horizontally on the original soil level without digging. Solid waste is then packed over the next floor until reaching the specified level. It is necessary to make an embankment along the edge of the area to act as a wall or to support the compaction of solid waste. It also serves to prevent the wastewater caused by the degradation of solid waste from seeping into the outside area. This method is used for lowland or where that it has the groundwater level slightly lower than the surface of the soil (not more than 1 meter).

Figure 3 The area method

Trench Method

This landfill method starts from compaction of the solid waste into a thin layer on the level lower than the original soil level by digging the soil down to the specified level. Then, overlap compaction is continue until the piles are thicker until reaching the specified level. In general, the digging depth is determined according to the groundwater level. At least the level of the trench or the bottom should be less than 1 meter above the groundwater in the rainy season to prevent the contamination of groundwater. No embankment is required because the walls of the trench can be dug as a wall to support the compacted solid waste. Soil that is dug out can be used to compact solid waste.

Figure 4 The trench method

Canyon Method

This landfill method looks like a large basin which may occur naturally or may construct by digging of valleys, creek, mine ponds, etc. The methods for landfill and compacting of solid waste in each pond may differ depending on the topography of that area (Hoornweg and Bhada-Tata, 2012).

Figure 5 The canyon method

5.2.3 Goals and principles of SWM

The first goal of SWM is to protect the urban health, particularly that of low-income group whom most suffer from poor waste management. Secondly, SWM aims to promote environmental conditions by controlling pollution (including water, air, soil, and cross media pollution) and ensuring the sustainability of ecosystems in the urban region. Thirdly, SWM supports urban economic development by providing waste management services and ensuring the efficient use and conservation of valuable materials and resources. Finally, SWM aims to generate employment and incomes in the sector itself (Schubeler, 1996).

Solid waste is an important issue that many communities are currently facing some problems due to an increase in large amount of waste. SWM in each locality or community is often problematic in every step from the collection process to the end of waste disposal. There are a lot of waste being left behind which cause a foul odor. There appears a problem of finding a place to get rid of waste due to conflicts with the community. Since reduction of waste at the point of origin, appropriate collection and transportation, and efficient disposal and treatment are enable to

more efficient SWM without causing further environmental and health effects (Bangsaeng, 2010).

SWM means collection, transport, recovery, and disposal of waste, including the supervision of such operations and aftercare of disposal sites. The purpose of waste management is the protection of the environment, human health, and natural resources. SWM also includes the system to provide information, education and raising of community participation.

SWM is the control of waste. It has activities to protect human health and the environment and resources conservation. Waste related activities include waste creating processes, waste handling as well as waste utilization. Control of these activities occurs based on the considerations prescribed earlier, purpose readjustment, structure, and state manipulation. The main objective of SWM must be besides waste avoidance, turning waste into non – waste and preventing waste from final disposal, especially of such disposal which does not utilize waste by any means (Pongrácz 2002).

SWM adheres to the principle of minimizing the amount of solid waste at the source before being disposed by incineration or landfill in the final step. The concept of SWM is shown in Figure 6.

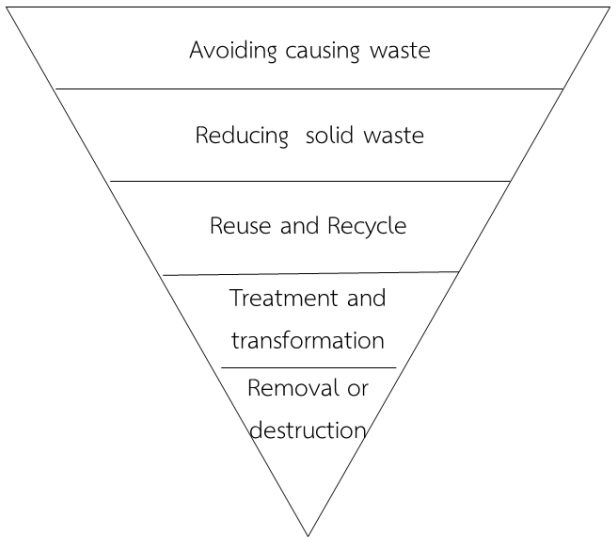


Figure 6 The concept of solid waste management

Reduction and separation at the sources

Waste reduction and separation at the point of origin should be done. It is the direct responsibility of the owner of the house, and building. This can be done by different approaches including;

- Avoid buying products are used multi – layer packaging.

- Avoid using single-use or low-lifespan products when choosing products used in daily life. For instance; soap, toothpaste, detergent, bleach, and so on.

- Choosing only products with larger sizes because the packing is less compared to the weight unit of the product.

- Avoid buying products containing waste that has been polluting the environment such as foam boxes and plastic bags.

- The selection of products that could be returned to the manufacturers. Choose to buy products whose manufacturers have recalled the remains of the packaging after consumption of the public.

- Choose to buy products that have a deposit refund system. For instance; products in the category of bottled soft drinks or bottled water.

- Determine to buy products that could be reused or recycled or contained various recyclable materials.

- Reuse means taking products that have been used and used again without having to go through any changes or forms. Better to buy or use products that designed to be used more than one time. Determine refill products.

- Repair appliances and equipment to be able to continue to use again or maintain for a longer life.

Collection and storage

The collection and storage process after the waste generated is extremely important. Some types of waste has the potential to be reuse or recycle before contaminated with other waste. After sorting, the general waste are collected by the collection truck and transported to the landfill site. Waste separation at sources before collection can reduce the amount of waste before disposal. The collection

and accumulation of these reuse and recycle waste for selling to the recycle plants can bring some extra income. However, the process of cleaning and sorting is time consuming and costly.

Transport

Transportation is the process to move solid waste from waste collection points for disposal to prevent the decomposition of total garbage and to minimize the amount of waste left over at various locations. It is a duty in accordance with the provisions of the law that local government organizations and sub-district administration organizations are responsible. Therefore, administration organizations must have a systematic plan and plan for waste transportation that occurs each day.

Transformation

Transformation is the way to change the form of solid waste collected from the community in the condition that is convenient for collection, disposal, destruction or reuse. The purpose of waste conversion is to increase the efficiency of the SWM system. Compressing of the waste into bundles or in lumps can reduce the area of solid waste collection, lower volume and reduce the cost of transportation to the landfill site. In addition, compacting solid waste before dumping to the landfill helps the landfill site last longer.

Removal or destruction

Removal or destruction is the final step in SWM after the process mentioned above have been carried out. The remained solid waste that cannot be recycled is transported to the landfill site for further disposal.

6. Integrated waste management

Integrated waste management is the concept for design and implementing new waste management systems and for optimizing existing systems. This concept, a comprehensive waste prevention, recycling, composting, combustion, landfill, and disposal program and management activities are combined in a proper design, construct and planning. Currently, the development of new policies, regulations and waste management business as an industry, non- technical components including

public engagement and education are unavoidable (Wong, 2016). Integrated waste management process is shown in Figure 7.

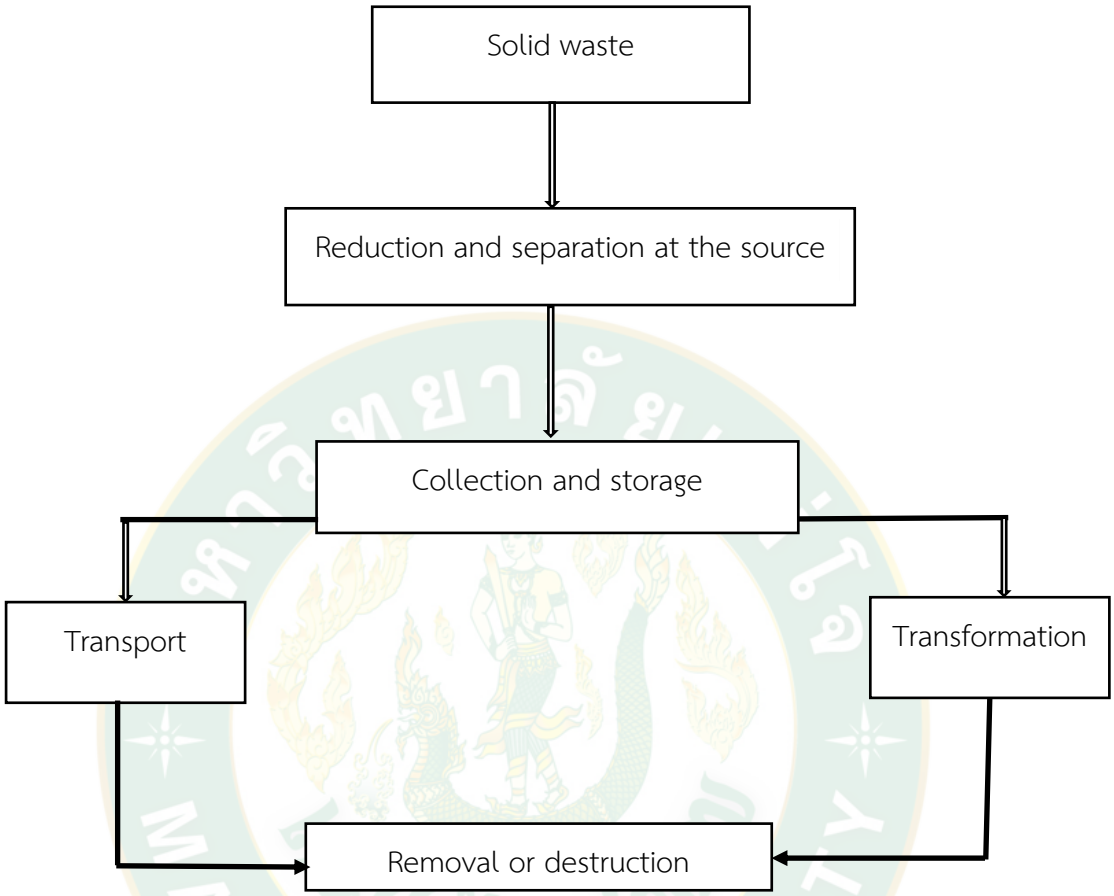


Figure 7 Integrated solid waste management procedures

7. Sustainable development

Sustainable development is the development of community that meets the need of the present without compromising the ability of future generations to meet their own needs. The sustainable development goals are as follows:

1. End poverty in all its forms everywhere.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. Ensure healthy lives and promote well - being for all and all ages.
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. Achieve gender equality and empower all women and girls.

6. Ensure availability and sustainable management of water and sanitation for all.

7. Ensure access to affordable, reliable, sustainable, and modern energy for all.

8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.

9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

10. Reduce inequality within and among countries.

11. Make cities and human settlements inclusive, safe, resilient, and sustainable.

12. Ensure sustainable consumption and production patterns.

13. Take urgent action to combat climate change and its impacts.

14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

15. Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably mange forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels.

17. Strengthen the means of implementation and revitalize the global partnership for sustainable development (Grossman, 2015).

8.Related research

In this work, recent research and methods related to solid waste management and strategic planning of solid waste management are explained below:

8.1 Solid waste management

Burnley (2007) studied chemical composition of waste in the UK and in Europe. The results of chemical surveys from Europe were compared. They concluded that these potential pollutants tended to be concentrated in the metals, batteries and electronic equipment and, to a lesser extent, in the unclassified material and the leather/ rubber fractions. Plastics tended to have elevated

concentrations of cadmium compared to the other fractions. The chemical and physical composition data were used to determine the possible potential pollution in the integrated solid waste management system combining between recycling, composting, incineration, and landfill. This case study showed that integrated waste management strategies cause the translocation of lead from composting and recycling into incineration. However, additional work is needed to determine the distribution of mercury and its fate.

Dahlen and Lagerkvist (2008), studied 20 methods and 7 types of waste sampling from reviews papers. The overall objective was to make a decision for planning and development of municipal solid waste, especially source sorting systems. The main question raised here was how to conduct household waste composition studies. The questions were divided into the following three parts such as overview of known methods; sampling and the waste components. The results showed that households' behaviors, sampling at the household level and analyzing each waste bin separately was recommended. Local seasonal variations in waste generation should also be considered.

Ngoc and Schnitzer (2009) investigated the sustainable solutions for solid waste management in southeast Asian countries. Human activities create waste and the quantity tends to increase as an increase in the demand for quality-of-life. In the end, waste treatment and waste prevention approaches need to develop into sustainable waste management. This reflected in the word the concept of " Zero Emission" which can be applied in the agricultural processing industry. The modern waste management in Southeast Asian countries was discussed in this article, followed by the rate of waste, sources and composition, and future waste trends. In addition, there were some reviews of waste management practices. This article focused on the concept of waste prevention through the use of all waste as a production process, leading to the possibility of creating an ecological chain of materials. In this article, the use of renewable energy and economic aspects were considered to solve the environmental and economic problems and goals for energy

saving. There is also discussion about the opportunities and limitations of waste management.

MacRae and Rodic (2015) studied the solid waste management in Bali. Samples were collected during seven weeks in 2014 and 2015. The key method was participant-observation with flexible and dynamic combination of conversations and interviews. The research showed and examined the challenges of waste collection and proposed the raising of public awareness and household waste management. Moreover, it focused on small cities which were different from those in large cities that usually receive more political attention.

Lee et al. (2016) studied a mathematical model for municipal solid waste management in Hong Kong. This article reviewed waste management guidelines and suggested mathematical models as a useful tool for decision makers to select a suitable option and cost saving. The A mathematical model in this work adopted from integer linear program and mixed integer program. The daily cost for the mathematical model with mixed integer program was HK$247,144.5, which is lower than the mathematical model with the integer linear program. Both approaches suggested to construct the incinerators at Shek Kwu Chau and Long Gang, and one replacement truck warehouse at Yuen Long.

Guerin et al. (2018) studied the importance of characterizing residual household waste at the local level: a case study of Saguenay, Quebec (Canada). In this work, the amount and type of residual household waste (RHW) generated by populations were identified. They suggested it was essential for the development of low cost waste management strategies to be effective and sustainable. Household waste was collected from urban and rural sectors that were representative of the study territory during the winter, summer, and fall of 2014. A total of 3039 kg of RHW was collected and sorted into 9 categories and 39 subcategories. Statistical analysis showed, except for organic matter, that the percentage of each category among sampling periods or locations were not significantly different. Organic matter made up the majority fraction of the RHW (53% to 66%). This was followed by plastics (9%), bulky items and renovation/demolition debris (6%), textiles (5%), metals (4%), paper and cardboard fiber (4%), glass (2%), and household hazardous waste (2%).

This approach allowed us to improve the accuracy of the data used in MRM, to create a regional waste dataset, and to develop a methodology more applicable to local realities.

Vassanadumrongdee and Kittipongvises (2018) identified factors influencing source separation, intention and willingness to pay for improving waste management in Bangkok, Thailand. This study recognized the separation of recycling sources as a sustainable way to manage community waste. However, most developing countries, including Thailand, are facing the lack of recycling facilities and source separation practice. According to the survey questionnaire, this study examined the willingness to separate and the willingness to pay (WTP) for the improvement of waste services and recycling facilities (n= 1,076). This survey highlighted the inconvenience and distrust of garbage collection as a major obstacle in waste separation. Promoting the separation of workplace sources can overflow people's intention to recycle waste at home. There was a positive correlation between waste separation and WTP (P>0.001). Besides, the average WTP was higher than the rate of garbage collection services available. This showed the satisfaction of Bangkok residents towards recycling program. However, the WTP numbers were still much lower than the average waste management cost.

Fan et al. (2019) studied the motivation–intention behavior model on household solid waste sorting in China and Singapore. The rapid economic growth and expansion of the city resulted in various problems related to sustainable development. The continued increase in household waste is a major problem worldwide, while waste separation is an effective way to reduce waste. However, low household waste recycling rates are common in many countries. This study used the planned behavior theory (TPB) to create a model of "motivation–intention– behavior to illustrate the ancestral system of waste separation behavior in households. Comparative studies were conducted to explore similarities and the differences between factors and behavior in Shanghai and Singapore. A survey of 1,100 city residents from both locations was conducted. The results showed that general motivation and specific environments had a great influence on behavioral intentions. In addition, direct influence, and control of factors on waste separation behavior

were important. Habit factors also affected behaviors. In addition, the theory of environmental interventions could be used as a basis for existing policies improvement.

8.2 Strategic planning of solid waste management

Gomez et al. (2008) determined urban waste generation and urban waste management strategies. The objective was to study the characteristics of waste generated in Chihuahua households and to compare the outcomes at economic and social levels. To identify socioeconomic trends in waste generation and characterization, 560 samples were collected in a period of one week from 80 households in Chihuahua and sorted by hand and classified as weight fractions. The results showed that increasing in waste generation associated with socioeconomic levels. The identification of the volume and composition of waste in the city was the first implementation step for the successful of waste management systems.

Suttibak et al. (2009) studied the comparison of economic tools for improving the performance of community garbage banks. The objective of this study was to increase the rate of public participation and recycling strategy for solid waste management. There were three community waste banks using economic tools to increase project efficiency for giving the member banks a profit, loans and incentives.

Verma et al. (2016) studied the municipal solid waste management in Ho Chi Minh City, Vietnam country. Current practices and future recommendation on waste management were also suggested. Data on waste generation in Ho Chi Minh City was collected from the Division of Solid Waste Management (DOSWM) of the Department of Natural Resource and Management (DONRE), Ho Chi Minh City. There are two landfill sites in Ho Chi Minh City, namely, PhuocHiep (Zone 1) and DaPhuoc (Zone 2). These landfill sites were equipped with heavy duty truck weighing machines. The weight of waste generated in Ho Chi Minh City was determined by subtracting the weight of truck without-waste from the weight of truck with-waste. Gaps analysis and SWOT (strengths, weakness, opportunities, and threats) were conducted. Solid waste generation in Ho Chi Minh City was about 8,175 tons/day, consisting 6,800-7,000 of MSW with 1.02 kg/capital/ day. Every year, about 10 times of MSW has been increasing, with major portion of food waste from the households, schools, and

hotels and restaurants. Current common practice of solid waste management in Ho Chi Minh City was landfill. About 86% of solid waste were transferred to two major landfill sites (PhuocHiep and DaPhuoc) and the rest was recycled. Paper, plastic, and metals are among major recyclable waste. The gaps analysis revealed that there are number of gaps in the regulation and economic policies, institutions framework and arrangements, technologies and infrastructure, capacity building, participation of stakeholders, and financing mechanism. One of the most important gaps was lacking of clear responsibility and accountability of authorities for the MSW management in Ho Chi Minh City due to involvement of multi agencies. The SWOT analysis pointed out that the private sector could play a vital role, as strength of city MSW management. Opportunities of foreign supports were strong due to the strategic location of Ho Chi Minh City in Southeast Asian region but increasing in population needed to be minimized.

Challcharoenwattana and Pharino (2016) studied a recycling program, willingness-to-pay study for enhancing municipal solid waste recycling in urban settlements in Thailand. The willingness to pay (WTP) for increasing recycling services in waste management in various communities in Thailand were identified. The WTP averages were identified by card payment method and analyzed by periodic regression. Questionnaire surveys were distributed manually to gather socio-economic factors related to recycling process. Results analysis showed that the monthly WTP averages increased with the smallest expansion (~USD 0.73). Recycling program, willingness -to-pay study could enhance municipal solid waste recycling in urban settlements in Thailand. The common factors that influence WTP were higher education and recycling waste habits. However, the result suggested that socioeconomic, and other recycling factors affected the willingness to pay. The average WTP from each school was consistently higher than the current waste disposal rate, which means that large number of respondents from all educational institutions liked recycling.

Das et al. (2019) reviewed scope and challenges related to sustainable waste management (SWM). SWM guidelines were modified to enable SWM to be more practical and effective along with the environmental regulations. Sustainability based

on “reduce”, reuse” and “recycle” (3R) were created. This research provided a broad overview of existing SWM strategies with the following key objectives; (i) to describe current technology, strategic innovation, and a comprehensive examination tool (ii) to show an overview of the nationwide waste management situation (iii) to identify the role of life cycle assessment (LCA) and other modeling tools in SWM and (iv) to show possible guidelines for sustainable recycling and waste utilization. The current investigations showed that the geographical location and economic status of most countries were important factors in determining the nature of waste. In addition, solid waste solid waste generation greatly varied among countries and waste composition was related to country's economic status. In this review, low-cost techniques (composting and vermicomposting) was emphasized for better management.

CHAPTER 3

MATERIALS AND METHODS

This research aimed to propose the sustainable strategy for solid waste management in the Beung Kiat Ngong Ramsar site in Pathoumphone district, Champasack Province, Laos PDR. It is important to quantify, identify and characterize waste generation and waste composition from the current situation. Opinions, awareness and attitudes towards waste management from communities and authorities were required. Moreover, the preliminary study of converting waste to value added products as well as an economic evaluation of each strategy were determined. The details are shown below;

1 Survey, selection, solid waste sampling and questionnaires

1.1 Survey and selection

There are eight villages in Beung Kiat Ngong Ramsar site in Pathoumphone district, Champassack province, Laos PDR. In this study, two villages that are Thahou village and Kiat Ngong village were selected. The population from both areas shows in table1. In the first survey in year 2020, the current situation of solid waste management from both areas were studied. Waste sampling was performed to get the background information of the amount of waste, waste composition and general information of each area.

Table 1 Population in study area

Village	Households					population				
						Children		Elderly People		
	Extreme poor	Poor	Fair	Wealthy	Total	< 14 yrs. Total	F	Total	M>60	F>55
Thapou	0	10	41	34	85	165	89	59	28	31
Kiat Ngong	0	6	134	32	172	341	121	90	40	50

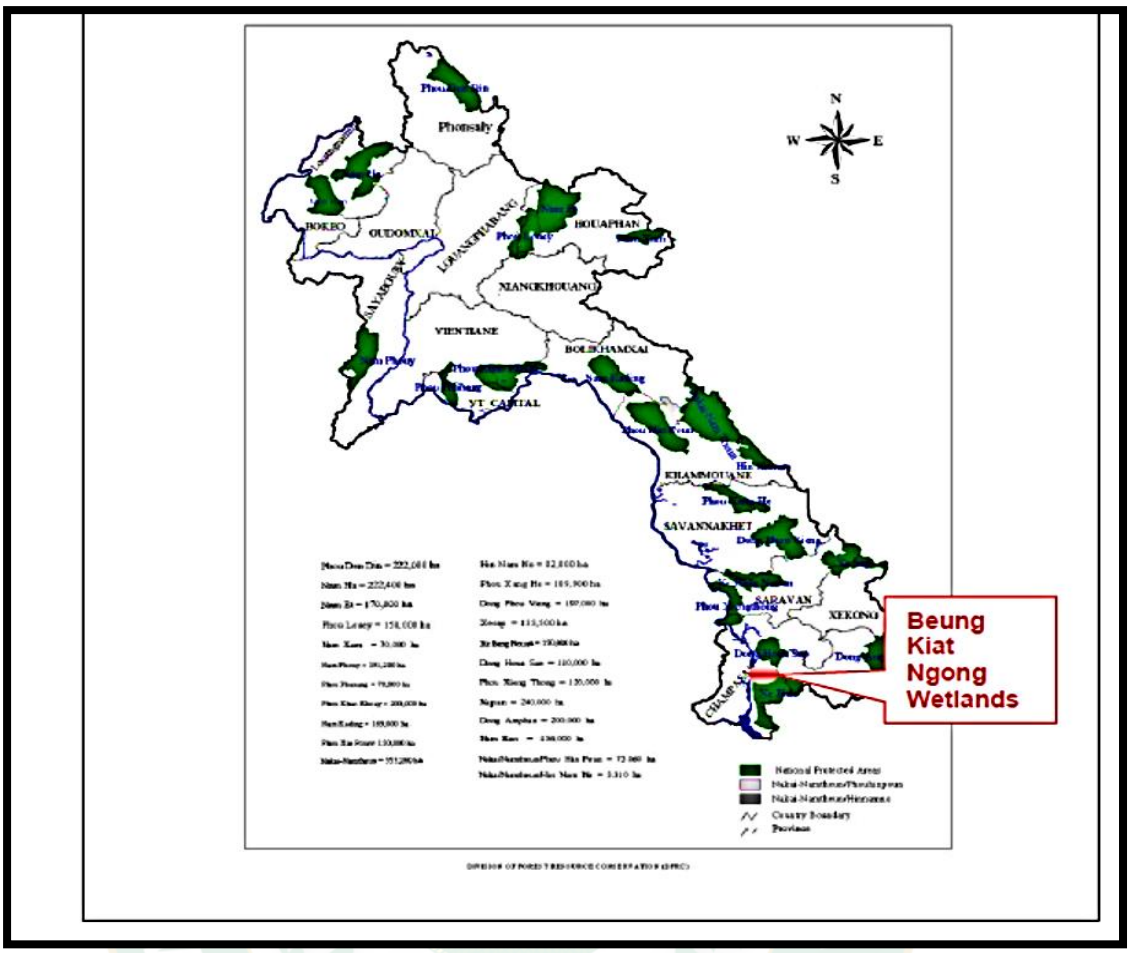


Figure 8 Map of Beung Kiat Ngong wetland, Pathoumphone district, Champasack Province, Laos PDR

1.2 Solid waste sampling

Solid waste sampling in this research included the process of collection, quantity determination, characteristics study, composition of solid waste determination and bulk density. At the beginning, the data collection and sampling from both villages was planned to conduct every trimonthly throughout the year according to seasonal changes. The waste was collected separately from each area without compacting and transported to a sorting spot. It was unloaded on a plastic sheet, and filled into the 100 L containers for weighing and temporary storage. The waste from Thabou and Kiat Ngong village were collected and further sorted as described later. Unfortunately, the planned has changed due to the pandemic of Corona virus disease (COVID -19) in the years 2019-2020. As a result, both Thailand and Laos were locked down and the sampling plan was cancelled. In this work, there

was only information of waste sampling from the first survey to discuss. Also, extra lab-scale of preliminary study of waste to value added product was performed.

1.2.1 The determination of quantity, characteristics, and composition of solid waste

Figure 9 sampling and sorting process (Quartering method) (Pollution Control Department, 2553). All collected waste from each area was mixed and selected for sorting separately according to types of material. In this work 6 material fractions (including general waste, paper, plastic, glass, aluminums, yard waste and hazardous waste) were separated. Each component was than weight for further calculation.

Approximately 1-2 cubic meters of solid waste

(a)

Throw the solid waste into the pile then spread and mix solid waste together that repeats 3 times.

(b)

(c)

Remove

Mix solid waste together

Remove

Figure 9 Sampling and sorting process (Quartering Method)

The percentage of solid waste was calculated from equation 3.1.

$$\text{The percentage of solid waste in percentage units (\%)} = \frac{W_1}{W_2} \times 100 \quad \text{.....(3.1)}$$

W_1 = the weight of the solid waste components 1 (kg)

W_2 = the weight of total of the solid waste components (kg).

1.2.2 Bulk density

Solid waste was taken into a container with known volume which was not less than 100 liters. The container was then raised up to 30 cm off the floor and allowed to hit the floor 3 times. If the amount of solid waste in the bin was reduced from the original level, more solid waste was added to the same level and repeated this step until the amount of solid waste was settled. The weight of both container and solid waste were measured. Triplicates were done to get the average normal density in kilograms per cubic meter using the equation below;

$$D\ (kg/m^3) = \frac{W_1 - W_0}{V} \quad \text{.....(3.2)}$$

D: Bulk density (kg/m^3)

W_0: weight of container (kg)

W_1: weight of container and the total of solid waste (kg)

V: volume of the container (m^3)

1.3 Questionnaires

In this work, opinions, awareness and attitudes towards waste management from communities (Thabou and Kiat Ngong village) and officers from department of natural resources and environment in Champasack province, Laos PDR were determined using questionnaires. In order to get the reliable responses and accurate results, the determination of survey sample size and population was conducted based (confidence level). The sample size was calculated from 25% of villagers' population (Sawadiyakorn, 2021). As a result, 50 respondents from each village were accidental selected. However, every officer from DNRE were selected as respondents as they were directly responsible for solid waste management. The questionnaire consisted of 4 parts including general information of respondents, knowledge,

attitudes, behaviors and recommendations for solid waste. The evaluation criteria for each part were indicated as shown below;

For the evaluation of part 2 and part 3 asking about knowledge and attitudes, it was classified into 5 levels of like scale as followed;

Like Scale		Grade level
Level 1: least agree	= 1	1.00-1.80
Level 2: Low agree	= 2	1.81-2.60
Level 3: Medium agree	= 3	2.61-3.40
Level 4: High agree	= 4	3.41-4.20
Level 5: Most agree	= 5	4.21-5.00

Moreover, the evaluation of the Part 4 asking about behaviors was classified into 5 levels of practical scale as followed;

Practical Scale		Grade level
Level 1: least practiced	= 1	1.00-1.80
Level 2: practiced at low	= 2	1.81-2.60
Level 3: moderate	= 3	2.61-3.40
Level 4: high performed	= 4	3.41-4.20
Level 5: most observed	= 5	4.21-5.00

2 Preliminary study of waste to value –added product

It was due to the pandemic of Corona virus disease (COVID -19) mentioned earlier, extra lab-scale of preliminary study of waste to value added product was performed using the information from the first survey. It was found that majority of golden apple snail shells (GAS) were dumped in the public area with not well managed. In this work, the idea of transform this shell waste into value added product; calcium carbonate ($CaCO_3$), was proposed. Incineration process was selected and its efficiency as well as effect of temperature was identified.

2.1 Experimental design for $CaCO_3$ production from (GAS)

The golden apple snail shells (GAS) were collected and preserved in 4°C for further analysis**.** In this work, the incineration process was applied to remove organic

substances and obtained $CaCO_3$ from GAS. The incineration temperatures were varied between 400°C, 500°C and 600°C. For each temperature, three treatments; (A) crushed before incineration (B) Incineration without crushing and (C) Control with no incineration and no crushing were conducted in triplicate (Figure 10 and Table 2). Before the experiment, GAS was cleaned in tap water and air dried. After that GAS samples were incinerated by the incinerator in an electric furnace under atmospheric pressure (Heraeus D-63450, Germany) for1 hour with the heating rate of 5°C/min. The samples were then crushed into powder for $CaCO_3$ determination by the EDAT Titrimetric method and atomic absorption spectrophotometry (AAS). The samples of control and the one with highest amount of $CaCO_3$ were sent for physical analysis and mineral composition using Scanning Electron Microscope and Energy Dispersive X-ray Spectrometer-SEM-EDS. All equipment used have been shown in Table 3.

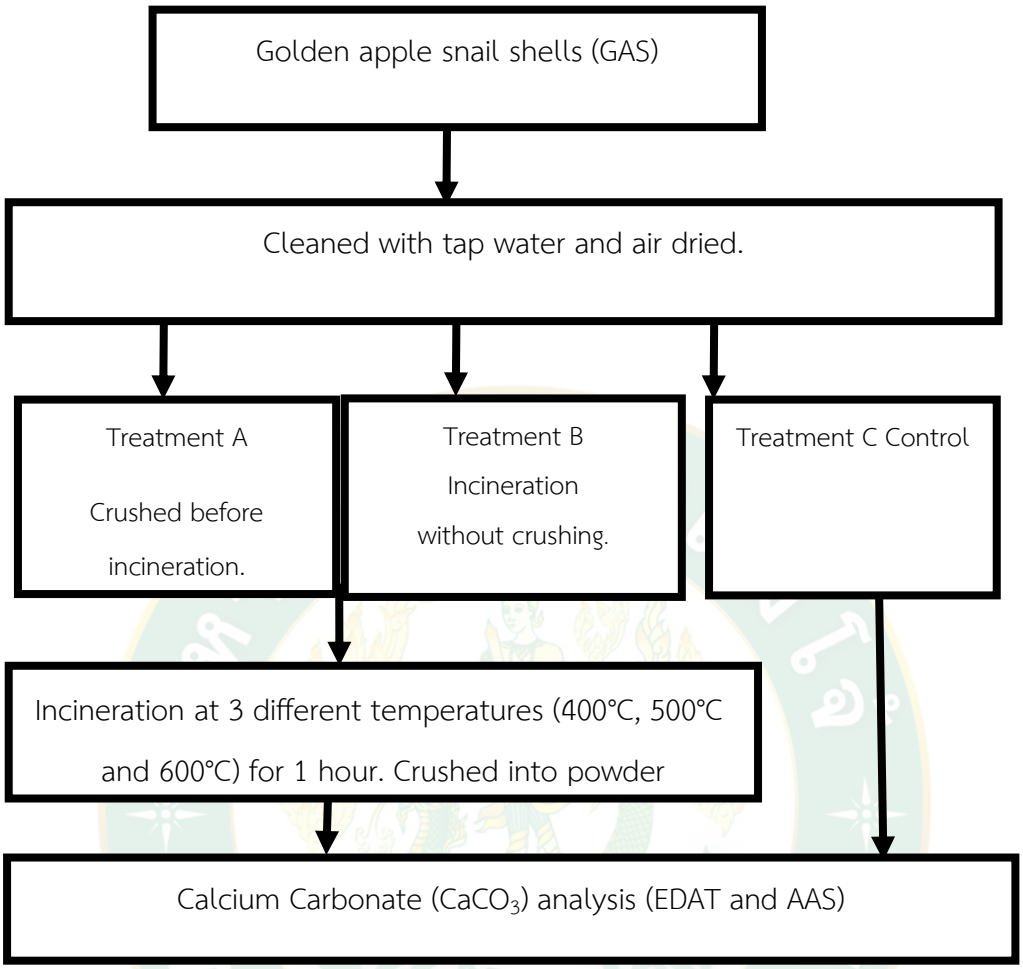


Figure 10 Flow diagram of experimental design

Table 2 Experimental design

Treatment	Temperature	Crushing	Incineration
A1	400°C	Yes	Yes
A2	500°C	Yes	Yes
A3	600°C	Yes	Yes
B1	400°C	No	Yes
B2	500°C	No	Yes
B3	600°C	No	Yes
C1	400°C	No	No
C2	500°C	No	No
C3	600°C	No	No

Table 3 Tools and equipment

Tools and equipment	Production company/ distributor	Countries
Analytical balance	Mettler Toledo PB3002-s	Switzerland
Vacuum evaporator	Buchi R-114	Switzerland
Incinerator	Heraeus D-63450	Germany
Atomic Absorption Spectrophotometry (AAS)	PinAAcle 900F /Perkin Elmer	

2.2 Determination of $CaCO_3$ by EDTA Titrimetric method

Calcium carbonate ($CaCO_3$) contained in GAS samples from three treatments was analyzed using EDTA Titrimetric method (APHA). 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 and titrated with EDAT standard solution using murexide as an indicator as explained elsewhere. The volume of EDAT used for titration (in milliliters) was multiplied by 20 to get the calcium carbonate value in mg/L as $CaCO_3$.

2.3 Determination of Calcium carbonate ($CaCO_3$) in golden apple snail shell (GAS) by atomic absorption spectrophotometry (AAS)

Approximately 0.1 g of GAS samples were prepared. It was then dissolved by 1% (w/v) of Hydrochloric Acid (HCL) (RCI labscan). After that, the samples were serially diluted by distilled water and adjusted to 50 ml (Pohl et al., 2020). After that, the data from AAS method (Ca values) compared with a standard curve.

3 Statistical analyses

SPSS program was used for static data analysis. Differences between groups or samples were deemed statistically significantly different at $p \leq 0.05$ using Two - way Anova.

4 Research duration

The duration of this research on the community based solid waste management at Beung Kiat Ngong Ramsar Site in Laos PDR was started from January 2020 to July 2021. Table 4 shows the timeline of this research.

Table 4 Timeline of research (29/12/2019-03/01/2020)

Contents	Months											
Year 2020	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1. Thesis proposal writing up	→	→	→	→								
Chapter 1: Introduction												
Chapter 2: Literature Review				→	→	→						
Chapter 3: Methodology						→	→	→	→	→		
Chapter 4: Results										→	→	
2. Thesis proposal defense											→	→
Years 2021												
3. Thesis writing up	→	→	→	→								
Chapter 5: Discussion												
4. Conclusions				→	→							
5. Completing thesis book				→	→	→	→					
6. Thesis defense					→	→	→					

5 Budget and expenses

This work was financial supported by Thailand International Cooperation Agency (TICA) In this research, the budget used were described as follows

Materials

Science equipment's in the laboratory = 5,000 Baht

Chemical = 13,000 Baht

Document materials

A4 = 1,000 Baht

Print out documents	= 5,000 Baht
Thesis book	= 8,000 Baht
Total	**= 32,000 Baht**

CHAPTER 4

RESULTS AND DISCUSSION

The Beung Kiat Ngong (BKN) Ramsar site, PathoumPhone district, Champasack province, Laos PDR has supported a human population of around 11,500 people from eight core villages. These villages are primarily reliant on subsistence agriculture, wild-capture fisheries, wild vegetables, and non-timber forest products for their livings (IUCN, 2012) . 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. There are large number of rice paddies found around the edge of wetland area. Apart from the income from agriculture products and fisheries, some income are also earned from tourism businesses, particularly in Ban Kiat Ngong. The information from department of information and tourisms of Champasack province reported that number of tourists has increased to 20,000 persons from 2013 to 2017 and these tended to be rising.

Significant factors responsible for environmental problem are climate change, and resource depletion, pollution and population growth. Solid waste is also one of the major global issues. The generation of waste and ineffective management have been causing negative impacts on the environment. Increasing in populations, agriculture productivity and number of tourists in Beung Kiat Ngong Ramsar site can affect higher amount of solid waste generation, resulting in the increase of the problem of waste disposal. This could have the impact on sustainable wetland management. Concerning to a decline in the environmental health of most inland and coastal ecosystems caused by the impacts of human uses, sustainable management practices of Ramsar site are crucially required.

Recently, sustainable development goals (SDGs) have been implemented to wetlands in order to conserve, wisely use and restore this precious resource. To achieve sustainable development, the Ramsar strategic plan is developed by the Ramsar convention on wetlands. The Ramsar site strategic plan 2016-2024 includes 4 goals and 19 targets. Sustainable integrated solid waste management approach is therefore, one of important issues to achieve SDGs for the promotion of sustainable

urbanization and economic growth (Grossman, 2015). If the proper waste management is established, it will be a great breakthrough in reducing air, soil and water pollution.

In this work, the researcher presented the current situation of solid waste management and waste composition from Thabou village and Kait Ngong village, Beung Kait Ngong Ramsar site. Also, community behaviors, knowledge and awareness towards waste management and the factors affecting solid waste management were illustrated. However, it was due to pandemic of Corona virus disease (COVID -19) in the years 2019-2020, both Thailand and Laos were locked down and the sampling plan was cancelled. Waste amount and waste characteristics reported in this work were from only the first survey. The extra lab-scale of preliminary study of waste to value added product was performed and apple snail shells waste were selected as raw materials for $CaCO_3$ production. Besides, preliminary waste management scenario framework for each village was proposed. The results are shown below.

1 The current situation of solid waste in Beung Kiat Ngong Ramsar site, PathoumPhone district, Champasack province, Laos PDR

1.1 The amount and composition of solid waste from two villages

In year 2020, Thabou village has 85 households with 224 populations, while Kiat Ngong village has 172 households with 431 populations. The majority of the population from both villages are farmers who mainly engage in paddy rice cultivation (IUCN, 2012), while people from Kiat Ngong village earn some extra income from tourisms. Moreover, the farmers from both villages also earn some income from selling meat of golden apple nail shells (GAS), which can be easily found in the paddy field area and wetland. It was found from both villages from BKN Ramsar site that 90% of these GAS shells peels waste were dumped in the public areas and they took a long time for natural degradation. In addition, solid waste was collected from households and dumped into local landfills without sorting and recycling (Figure 12-13). Once both landfills were full, all garbage were open burned. This process undoubtedly caused pollution problems in the wetland communities. However, this trash excluded food waste and agriculture residues which was used for animals feeding and composting.

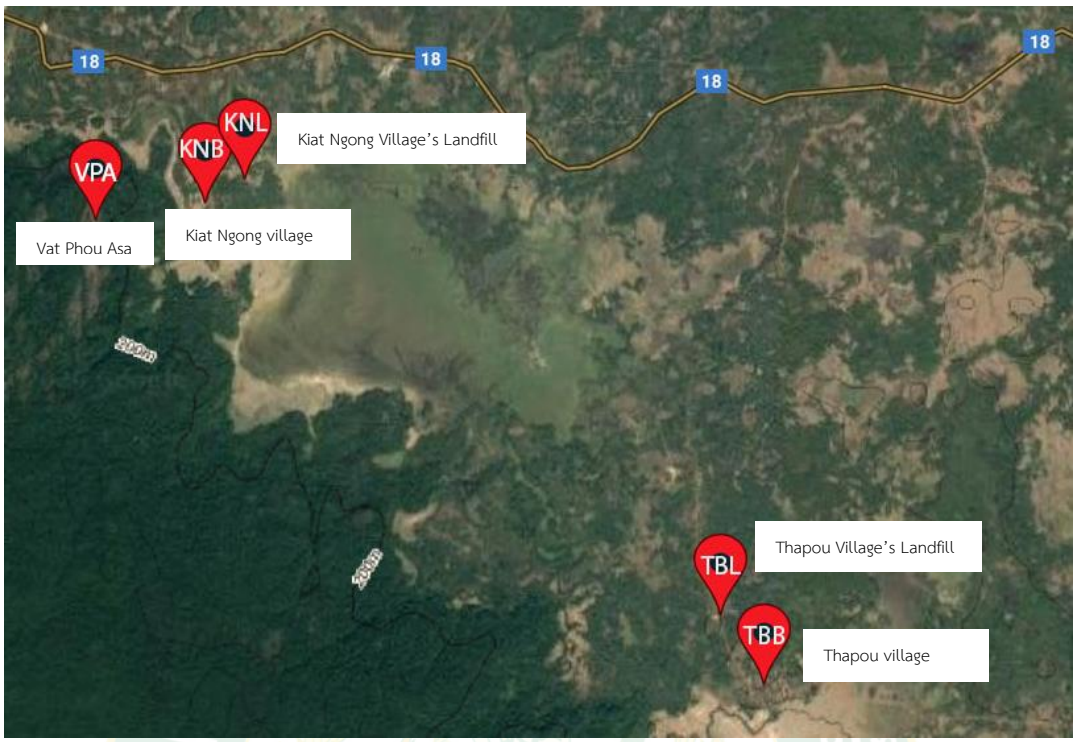


Figure 11 The map of the study areas including location of Thabou village, Kiat Ngong village and their local landfills

Figure 12 Thapou village's landfill

Figure 13 Kiat Ngong village's landfill

Solid waste was collected in 3 days from two villages during dry season in 2020; Thapou village and Kiat Ngong village. The result found that Thahou village generated a daily average solid waste of 3.6 kg/day (Table 5), which was higher than Kiat Ngong village that generated approximately2.3 kg/day.These figures represented only waste collected from households, which does not include food waste and agriculture residues as mentioned earlier. The number was obviously quite low as the majority of solid waste in the rural area was mainly food waste. However, the data shown still was not a presentative number of waste generation of both area as the researcher had only one chance to go sampling in the villages. More sampling are required for future work.

Although, Thabou village had lower populations, higher waste generation was obtained due to additional waste from school activities apart from household's and agricultural activities. However, the amount of waste from both villages (defined as local areas), were approximately 20 times less than the one from the big city of Laos PDR. It was reported that Pakse city, Champasack province generated 53.8 kg /day of

solid waste (Aloon, 2015). This represented the impact of income level, economic and consumption habit or disposal habits of people. Lower income and way of life in the local community led to lower waste generation due to their low purchasing power of products (Yanasinee, 2019). Modern lifestyle has led to more acute waste problems, convenience products generally require more packaging, leading to greater quantities of waste, and higher proportion of non- degradable materials such as plastics and foams.

The result also indicated the variation of solid waste composition between both areas owing to different locations, sources, and activities (Table 5). It was found that the major source of solid waste generation in Thabou village was mainly from agriculture activities, school and households' activities (Figure 14), while solid waste from Kiat Ngong village was generated by the tourists and household. Kiat Ngong village has famous tourist sites, especially, elephant trekking which can be earned more than US$ 20,000 per year (IUCN, 2012). However, the survey result found that there were no trash bins available at the tourist places. As the resulted most of rubbish has been dumped in the public areas, while some were open burned or dumped into the landfill (Figure 15). This also happened in Thabou village where trashes were not separated from its source before dumping into the local landfill and no separate bins were available in the public area either. Backyard burning was, what is more, still common in many areas of both villages. This is because it is easier than hauling it to the local disposal site and paying for waste collection service (Awasthi et al., 2019). Apart from open dumping and open burning of solid waste from both villages, Unfortunately, numerous golden apple snail shells were found and open dumped everywhere in both areas (Figure 16). Large number of golden apple snail shells were observed in Ramsar site areas as it has become popular exotic food among Laos people (IUCN, 2012). This is no doubt that high amounts of shells, nearly 90% of total amount of solid waste, were generated with improper management which will be discussed later.

Table 5 Composition of solid waste in Thabou Village and Kiat Ngong village

Thabou Village			Kiat Ngong village		
Type of solid waste	Weight (Kg)	Percent (%)	Type of solid waste	Weight (Kg)	Percent (%)
Paper	1	9.1	Paper	1	14.3
Plastic	2	18.2	Plastic	2	28.6
Glass	2	18.2	Glass	0.5	7.1
Aluminums	1	9.1	Aluminums	1.5	21.4
Yard waste	4	36.4	Yard waste	0.5	7.1
Hazardous waste	1	9.1	Foam	1.5	21.4
Total	11	100	Total	7	100

Note: The data was collected in 29/12/2019 - 03/01/2020.

Figure 14 Current situation of solid waste disposal in Thapou village

a. b.

Figure 15 Current situation of solid waste disposal in Kiat Ngong village; (a.) Open dumping and b.) Open burning)

Figure 16 Golden apple snail shells (GAS) waste in public areas

Normally, the density of solid waste from high income countries was in the range of 100-170 kg/m^3, while the value in medium income and low-income areas were in the range of 170-350 kg/ m^3 and 250-500 kg/ m^3, respectively (Li, 2020). In this study it was found that the density of solid waste from Thabou village and Kiat

Ngong village were 550 kg/m^3 and 350 kg/m^3, respectively. The major reason for this difference between both areas is more plastic, paper, aluminum and foam observed in the waste from Kiat Ngong village compared to Thabou village. Moreover, this could be the result of socio-economic variables such as employment, education, number of members in the household and activities that reflects the variation of waste composition. Lower income community tends to have higher values of density due to higher organic fraction in the waste such as food and yard waste (Kaplan Mintz, 2019). On the other hand, solid waste from high income countries were mainly packaging such as plastics, paper and card board. However, this density number will be further used for the planning of solid waste transportation management from its source to landfills and waste disposal practices (Namjaitrong, 2018).

Considering solid waste composition in Thabou village, the highest percentage by weight of total solid waste generated was yard waste (36.4%) followed by plastic (18.2%) and glass (18.2%). The lowest proportion were hazardous waste (chemical fertilizer Sack) (9.1%), aluminums (9.1%) and papers (9.1%) (Figure 17). On the contrary, solid waste in Kiat Ngong village composed of large amounts of 28.6% plastic, 21.4% aluminums, 21.4% foam, 14.3% papers, 7.1% glass and 7.1%yard waste (Figure 18). This finding shows the variation of solid waste source between agricultural community (Thabou village) and local community with tourism destination (Kiat Ngong village). It is clear that Kiat Nnong village has lower waste generation, while having large amount of plastics and packaging waste compared to Thabou village. The reason would be that Kiat Nnong is a tourist site and this led to an increasing of the use for drinks in plastic containers and aluminium tin and can. Fraction of glasses in the waste was also found from both area due to the demand of energy drinks such as M150 bottles for male workers. It can be seen that these waste from both villages have high potential for recycling. Various sorts of yard waste from households, moreover, were found to be highest proportion in Thabou village. This waste should be managed by separating to make composting rather than dumping in the dump site (Namjaitrong, 2018). However, a lot of foam waste was found from Kiat Ngong village where more processed food and ready to eat food

were required. This waste is problematic as numerous hazardous chemicals, such as isocyanates, hydrocyanic acid, and dioxins, are released when these materials are incinerated or decomposed into hazardous when deposited into landfills (Petak, 2019). The reduction of using foam containers is also another challenge for this area. The overall results indicate the absence of a proper waste separation system from both areas. Also much revenue can be generated by recycling plastic, glasses, aluminiums, and paper which could also help to reduce resource depletion and sustainable waste management (Vassanadumrongdee and Kittipongvises, 2018).

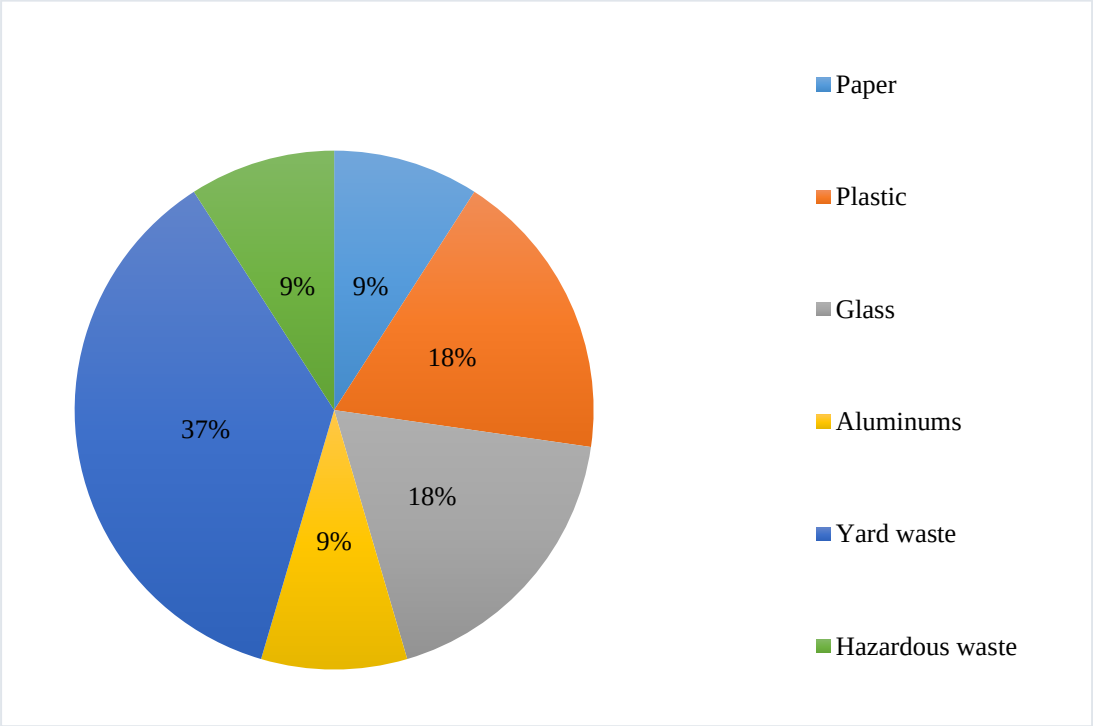


Figure 17 Composition of solid waste in Thabou village

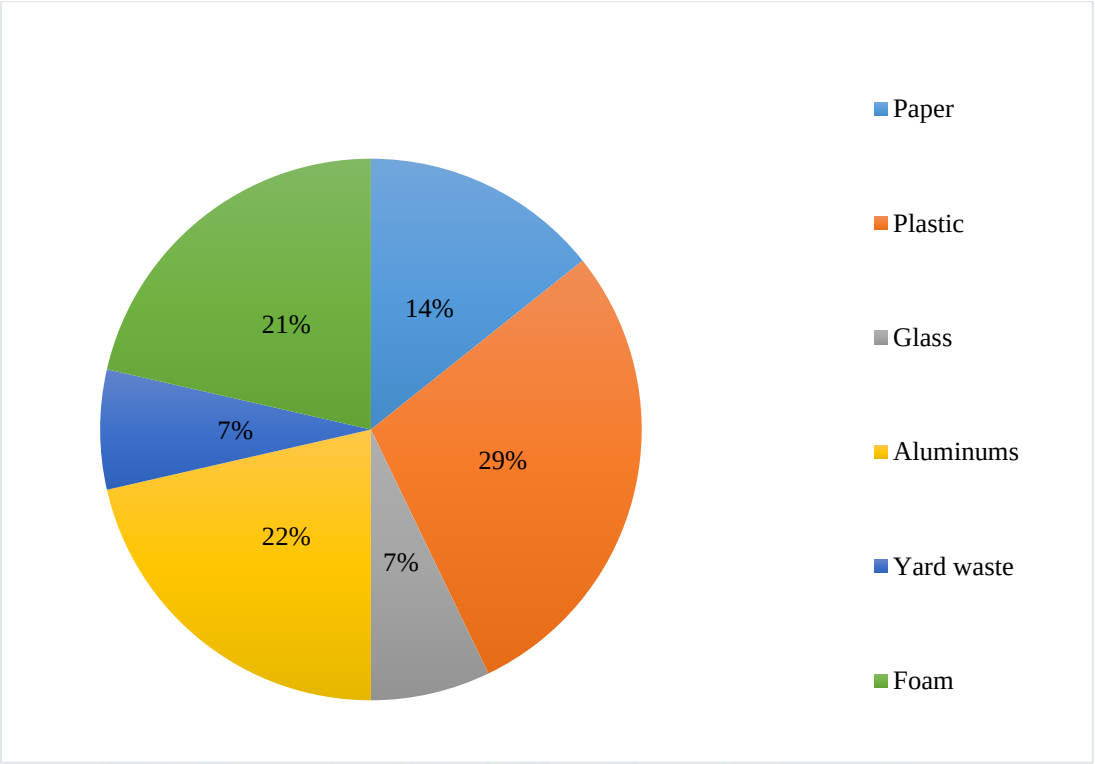


Figure 18 Composition of solid waste in Kiat Ngong village

From the above information, it shows characteristics and classification of solid waste and the current situation from both villages in BKN Ramsar site. However, more information about knowledge, attitudes, awareness, and understanding of solid waste management from community aspect are still required for future planning and strategic plans of solid waste management in BKN Ramsar site. Therefore, questionnaires asking about opinion, knowledge, attitude and behavior of local community on solid waste management from both villages were conducted. Thabou village has 85 households and Kiat Ngong village has 172 households (IUCN, 2012), while only 50 staff are currently working at the department of natural resources and environment in Champasack province, Laos PDR (DNRE, 2019). The sample size was calculated from 25% of villagers' population (Sawadiyakorn, 2021). In this work, 50 respondents from each village and officer from DNRE were selected. In total, 150 responses were obtained. The resulted from questionnaires from 4 parts as below:

1.2 Knowledge, attitude and behavior of local community on solid waste management in Beung Kiat Ngong Ramsar site

As mentioned earlier that sustainable waste management becomes an important strategic for Ramsar site development. Sustainable waste management is regarded as an effective measure to reduce the cost of collecting, transporting and processing waste. Sustainable waste management behavior is defined as an effort to reduce waste (reduce), reusing goods that are still feasible to use (reuse), recycling (recycle), or turning waste into energy sources (waste to energy). The success of sustainable solid waste management depends on the participation of communities and local authorities as well as private sectors.

This study examined the knowledge, attitudes, awareness status, behavior and practice concerning solid waste management (SWM) among villagers and local government staffs who are responsible for solid waste management. The knowledge possessed by respondents refer to their understanding of the topics related to sustainable solid waste management. Attitudes refer to their feelings towards sustainable waste management, as well as ideas preconceived which may lead to it. The practice refers to the way they show the knowledge and attitudes through their actions in implementing sustainable waste management.

To get more information of solid waste management in term of society knowledge, attitude and behavior in Beung Kiat Ngong Ramsar site, the questionnaires were distributed and collected. The samples consisted of 50 people from each village and 50 staffs from the department of natural resources and environment. The questionnaires consisted of 4 parts including general information of respondents, knowledges, attitudes, behaviors and recommendations for solid waste management.

1.2.1 General information of respondents from two villages

According to the data from Table 6, women accounted for highest sample population (70% and 64% for Thabou village and Kiat Ngong village, respectively). Also, the age of respondents from both sites was between 51-60 years which was

nearly half of the sample population (46% and 48% for Thabou village and kiat ngong village, respectively). The marital status of married made up about 74% and 78% of the sample population for Thabou village and kiat Ngong village, respectively. Moreover, half of respondents from both areas enrolled elementary school. However, there were no significant differences of respondent's information between both villages (P>0.05). From the result, it found that females were more in charge of all housework' s, while males are responsible for working. Woman, therefore, is recognized as the active role player in waste management from the household level. This becomes an important fundamental factor in planning on solid waste management policies in this area. Females were sensitive gender and had an influence on solid waste management such as in the separation of solid waste and household activities. Regarding to this findings, it can be linked to strategic planning in the villages such as training planning, activities and perceptions of the educational background which should focus on females target audience.

Table 6 General information of respondents from two villages

Assessment lists	Thabou village Valid percent (100%)	Kiat Ngong village Valid percent (100%)
Gender		
Male	30.0	36.0
Female	70.0	64.0
Status		
Married	74.0	78.0
Single	20.0	14.0
Divorced	0.0	2.0
other	6.0	6.0
Ages		
<20 years	2.0	2.0
21-30 years	18.0	18.0
31-40 years	16.0	10.0
41-50 years	18.0	22.0
51-60 years	46.0	48.0
Education		
Lower than elementary	10.0	16.0
Elementary	50.0	50.0
High school/Vocational	36.0	32.0
Bachelor's degree	4.0	2.0

1.2.2 Comparison of knowledge and understanding of solid waste management between Thabou village and Kiat Ngong village

The knowledge possessed by respondents refer to their understanding of the topics related to sustainable waste management. In this study, knowledge about sustainable waste management consists of four indicators which is waste sorting, 3Rs (reduce, reuse and recycle), composting, landfill disposal, waste to energy and improper disposal such as open burning and open dumping were evaluated. Table 7

contains the answers of respondents on knowledge and understanding on waste management with scale ranges from 1 (least agree) to 5 (most agree). The result shows that the highest score of waste management knowledge and understanding of both areas considered to be open dumping and composting with the value of 35.4% and 32.7% for Thabou village and 47.1% and 42.2 % for Kiat Ngong village, respectively. Open burning was accounted for 9.7% of the respondents from Thabou village which was higher than Kiat Ngong village.

Interestingly, both villagers understood waste sorting process and more people from Thabou village was reported (12.4% and 5.9% of respondents from Thabou village and Kait Ngong village). Similarly, people from both areas realized how to manage waste using 3Rs while higher percentage was found from Thabou village. Although quite a number of the respondents have knowledge concerning solid waste management, but it is not consistent with their practical's as recyclable waste as well as large number of organic matters were dumped in landfills. It was found that none of the respondents from Kiat Ngong village has recognized landfill management (0.0%). Also, knowledge of waste to energy was still new for both communities. It appears that the success of solid waste management not only depends on the participation of local communities but also their knowledge and understanding. This finding shows that providing all knowledge and understanding of solid waste management are crucially required.

Table 7 Comparison of knowledge and understanding of solid waste management between Thabou village and Kiat Ngong village

Assessment lists	Thabou village (%)	Kiat Ngong village (%)
Sorting by bin types	12.4	5.9
3R (reduce, reuse and recycle)	4.4	2.0
Local Landfill	5.3	0.0
Waste recovery	0.0	0.0
Composting	32.7	42.2
Open dumping	35.4	47.1
Open burning	9.7	2.9

1.2.3 Opinions on solid waste management, waste separation and 3Rs for solid waste management between Thapou village and Kiat Ngong village

Table 8 shows that the highest score of the opinion is strongly agree on the community benefits obtained from waste management (4.44; SD ± 0.81 and 4.42; SD ± 0.67 for Thabou village and Kiat Ngong village, respectively). This means that the respondents attached great importance to solid waste management. Also, the respondents from Thabou village agreed that lacking of consciousness, awareness, and understanding were causes of solid waste problems (4.30; SD ± 0.73). Moreover, respondents recognized that attaining a sustainable waste management was a joint responsibility of the government and its community members.

From the results above (Table 7), it is obvious that most of people in communities recognized waste management using open dumping method, while small amount of waste separation and 3Rs (reduce, reuse and recycle) method was pointed out. However, it can be seen from Table 8 that respondents from both villages still had the positive opinion towards waste separation and 3Rs (scored with the level 3 to level 5). Interestingly, the result indicated that more respondents from Thabou village recognized 3Rs (reduce, reuse and recycle) than Kiat Ngong village as

shown by high and higher score in related 3Rs topics). This coincides with the result obtained from Table 7, where more percentage of people from Thabou village knowing and understanding about 3Rs was observed. However, there were still misunderstanding about several issues such as hazardous waste management, plastic and foam disposal, proper recycle waste handling and meaning of each separate bin types.

This 3Rs is one of the basic solid waste strategies that can be developed in the local communities and their participations is also important for its success (Vassanadumrongdee and Kittipongvises, 2018). Moreover, it is important that the participation of both local communities should be initiated by separating waste at household level (or separation at source) and handling over separated waste to the waste collector. Organic wastes can be separated and composted in backyards to reduce its amount dumped in landfills, especially in Thabou village. The major recommendation of the study is the needs to put more effort into providing knowledge on waste separation and 3Rs to local communities. This could improve lifestyle of people in the community and support sustainable solid waste management in area. Moreover, scientific knowledge on individual, as well as community aspects of recycling and waste minimization can also help to design more waste management strategies (Kaplan Mintz, 2019).

Table 8 Knowledge and understanding of solid waste separation and 3Rs policy for solid waste management in Beung kiat Ngong Ramsar site

Like Scale: Level 1: Least agree, Level 2: Low agree, Level 3: Medium agree, Level 4: High agree and Level 5: Most agree.

Assessment lists	Thabou village			Kiat Ngong village		
	Mean	Std. Deviation	Like scales	Mean	Std. Deviation	Like scales
1.Solid waste separation is difficult and complicate. However, it should be done to reduce environmental problems.	4.18	1.02	High Agree	4.16	1.02	High Agree
2.Solid waste separation by types of bin types is time consuming.	3.42	1.31	High Agree	2.98	1.30	Medium Agree
3.Solid waste management give the benefits to community.	4.44	0.81	Most Agree	4.42	0.67	Most Agree
4.The solid waste separation that is the good way to solve environmental problems.	4.20	1.08	High Agree	3.80	1.21	High Agree
5.Food waste and water should be separated from recycle waste before dispose.	3.72	0.93	High Agree	3.04	1.03	Medium Agree
6.Plastic bag and foam can be naturally degraded in a	3.50	1.54	High Agree	3.04	1.31	Medium Agree

Assessment lists	Thabou village			Kiat Ngong village		
	Mean	Std. Deviation	Like scales	Mean	Std. Deviation	Like scales
short time.						
7.Solid waste such as food waste, vegetable and fruit peels should be disposed in wet bin (organic waste bins)	4.06	0.91	High Agree	3.82	0.66	High Agree
8.Using reusable containers instead of plastic bags such as food containers, basket, cloth bags can reduce the amount of general waste.	4.08	1.10	High Agree	4.02	0.94	High Agree
9.Recycle waste such as paper (A4, cardboard, books) are less value and cannot be recycle. It should be separated and disposed in the general bin (dry waste bins).	3.66	1.13	High Agree	2.94	0.98	Medium Agree
10.Straws, coffee mugs, plastic, snack bags must be disposed in the general bin (dry waste bins)	4.14	0.76	High Agree	3.40	1.14	Medium Agree
11.Solid waste separation is the responsibility of the authorized person such as local municipality	3.88	1.46	High Agree	3.32	1.69	Medium Agree
12.Causes of solid waste problems comes from lacking	4.30	0.73	Most Agree	3.66	1.04	High Agree

Assessment lists	Thabou village			Kiat Ngong village		
	Mean	Std. Deviation	Like scales	Mean	Std. Deviation	Like scales
of consciousness, awareness, and understanding.						
13. Waste separation before disposal reduced the process of solid waste management.	3.96	1.14	High Agree	3.78	1.13	High Agree
14.Hazardous waste management used the same methods as general waste management	3.20	1.30	Medium Agree	2.60	1.18	Low Agree

Note: 1.00- 1.80=Least agree, 1.81-2.60=Low agree, 2.61-3.40=Medium agree, 3.41-4.20=High agree and 4.21-5.00=Most agree.

1.2.4 Comparison of the attitude on solid waste management between Thabou village and Kiat Ngong village

The success of a solid waste management program lastly depends on household participation. This participation depends on the attitudes and behaviors of the society. A better understanding of society behaviors and attitudes will help decision maker to design and improve effectiveness of solid waste management policy (Ngoc and Schnitzer, 2009). Results showed that the communities' attitudes concerning solid waste management were highly agree and mostly agree for Kiat Ngong village and Thabou village, respectively (as shown in Table 9). This result indicated that Thabou village was considered as having better positive attitudes on solid waste management. The most agree scale on willingness, learning and training on solid waste management of Thabou village was obtained with the mean value of 4.44 ± 0.79. Although people from both villages showed the willingness to solve solid waste problems, the results mentioned earlier demonstrated that knowledge and understanding on solid waste management as well as best practices was still lacking.

From the results, it has become clear that there is still a need to educate the communities about the problem caused by solid waste as this helps in raising their attitudes and awareness about the problem and their support in community waste management. Some studies show that education plays a role in developing people's attitudes towards the environment. People are always adopting, modifying, and relinquish attitudes to fit the ever-changing needs and interests after being education (Desa, 2011; Ahmed & Mohammed Al- Mekhlafi 2009). Although there some suggest that there is no relation between education and attitude cannot be changed by simple education (Al-Najede 1990; Lyons & Breakwell 1994 and Howard Johnston & Ronad Williamson2013). Acceptance of new attitude depends on who is presenting the knowledge, how it is presented, how the person is perceived, the credibility of the communicator, and the conditions by which the knowledge was received. Thus,

great support from local authorities is also one of key factors for the success of waste management which will be discussed later.

Table 9 Comparison of the attitudes on solid waste management between Thabou village and Kiat Ngong village

Like Scale: Level 1: Least agree, Level 2: Low agree, Level 3: Medium agree, Level 4: High agree and Level 5: Most agree.

Assessment lists	Thabou Village			Kiat Ngong Village		
	Mean	Std. Deviation	Like Scales	Mean	Std. Deviation	Like Scales
1. You have a willingness to separate solid waste in your households.	4.26	0.85	Most Agree	4.28	0.76	Most Agree
2. You feel involved to solving solid waste problem and ready to make efforts to solve the problem.	4.08	1.03	High Agree	3.74	1.03	High Agree
3. You want to attend training on solid waste management whenever you can.	4.36	0.92	Most Agree	3.82	1.02	High Agree
4. The government should provide training on solid waste management in the village.	4.44	0.79	Most Agree	3.80	0.97	High Agree
5. You think that the solid waste problem is your responsibility.	4.74	0.49	Most Agree	4.46	0.61	Most Agree

Note: 1.00- 1.80=Least agree, 1.81-2.60=Low agree, 2.61-3.40=Medium agree, 3.41-4.20=High agree and 4.21-5.00=Most agree.

1.2.5 The behaviors and practices concerning solid waste management from two village

Results from Table 10 showed that the communities' behavior and practice concerning solid waste management for Thabou village were moderate (level 3), which was better than the one from Kiat Ngong (level 1). It was also found that Thapou villagers had moderated discipline on waste separation and 3Rs, which correspond to results obtained from Table 8 and Table 9 where better knowledge and understanding and attitudes were observed. Despite the high status of awareness and attitudes expressed by respondents concerning SWM, their behaviors and practices and willingness to act towards this problem was still average and low (mean 2.72±1.37 for Thabou village and mean 2.32±1.10 for Kiat Ngong village). Moreover, both villages showed least behaviors and practice in solid waste separation from its source with the value of mean 2.30 ± 1.23 for Thabou village and mean 1.98 ± 1.06 for Kiat Ngong village, respectively (Table 10). This result supports the relationship between their behaviors and attitudes and their knowledge (details as above). The factors that possibly affected their behaviors could be knowledge, beliefs, attitudes, attitudes values, motivation and determination to behave (Fan et al., 2019). It is apparent that there is the necessity to develop communities' attitudes and willingness to reduce problems related to SWM. However, the transfer from attitudes to behavior can also be affected by lifestyle, while some people might not be ready to change their lifestyle in ways that might mean sacrificing certain forms of leisure and comfort for the sake of the environment. This is still a big challenge, especially in the low-income communities where the economic aspect to earn a livelihood is the first priority and environment is less attractive.

Additionally, considering the resulted from Thabou village and Kiat Ngong village, there were significant differences between the mean scores of knowledges, understanding, awareness between villages (T-test, $P \leq 0.05$) whereas no significant difference was observed for other variables such as attitudes and behaviors (T-test,

P>0.05). From the results, it is obvious that both villages still lack of knowledge and understanding of solid waste separation and 3Rs. However, it can be seen that more activities on solid waste separation and 3Rs found from Thabou village than Kiat Ngong village. The community' s behavior and practice concerning solid waste management for Thabou village were moderate (level3), which was better than the one from Kiat Ngong village. Thabou village had better attitude and behavior towards solid waste management. From the results obtained, communication and education efforts to increase knowledge on issues relating to solid waste management and the environmental concerns should be considered to encourage their behaviors and practices. Workshops and trainings on waste separation and 3Rs should be promoted by the authorities. Budget and facilities related to waste management such as separated bins or recycle bins should also be provided. Waste management service such as collection, transportation, sanitary landfills should be facilitated within the context of Ramsar area.

Table 10 The behaviors and practices about solid waste management from two villages

Like Scale: Level 1: Least practiced, Level 2: Practiced at low, Level 3: Moderate, Level 4: High performed and Level 5: Most observed.

Assessment lists	Thabou village			Kiat Ngong village		
	Mean	Std. Deviation	Like Scales	Mean	Std. Deviation	Like Scales
1.Separation of solid waste before disposal.	2.30	1.23	Practiced at Low	1.98	1.06	Practiced at Low
2.Separation and collection of organic waste for animal feeding and composting.	3.06	1.45	Moderate	2.80	1.23	Moderate
3. Reuse plastic bags.	3.38	1.40	Moderate	2.88	1.45	Moderate
4. Disposal of golden apple snail shells in the village's landfill.	3.18	1.49	Moderate	2.20	1.18	Practiced at Low
5. Open burning of agriculture residues.	2.72	1.37	Moderate	2.32	1.10	Practiced at Low
6. Reuse cans.	2.80	1.26	Moderate	2.30	0.95	Practiced at Low
7. Collection of glass bottles and plastic bottles for sale	2.66	1.49	Moderate	2.48	1.26	Practiced at Low
8. Washing of plastic bags and foam before throwing into the bin.	2.64	1.39	Moderate	2.24	1.04	Practiced at Low

Note: 1.00- 1.80=Least practiced, 1.81-2.60=Practiced at low, 2.61-3.40=Moderate, 3.41-4.20=High performed and 4.21-5.00=Most observed.

Besides the information from villagers in Beung Kiat Ngong Ramsar site, the background knowledge, awareness and behaviors of the authorities towards solid waste management are very important for the development of solid waste management strategy in the area. In this work, the questionnaires were also distributed to staffs from the department of natural resources and environment in Champasack province. The response resulted describe below.

1.3 Solid waste management information from staff of the department of natural resources and environment in Champasack province (DNRE)

1.3.1 General information of respondents from DNRE

It can be seen from Table 11 that male accounted for highest sample with the value of 68.0 % . Also, the majority of staff age was between 31-40 years old (78.0%) with the marital status of 66.0% married. In addition, it is obvious that most of respondents had a bachelor's degree with approximately 76.0 % , while having lower number of master's degree (24.0%). Nearly 60 % of respondents have been working for 4-6 years, only 20% had the working experience between 12- 20 years. From the result, it is clear that the staff in DNRE has higher education than the villagers. Apparently, more male workers worked in the government sector than the females.

Considering their working experiences on solid waste management, the results revealed that (Table 12) more than half of them (58.0%) have experience for 4-6 years and education level of a bachelor's degree. Followed by 32.0% of policymaker, who creates ideas and plans, especially carried out by wetland project and other projects under Laos government with the experience for 12-20 years. Moreover, 8.0% were the coordinator staff with the working experience between 7-11 years and have education level of master's degree. The findings showed that all respondents were officers who worked under environmental section with related solid waste projects which should understand the role of waste management and have practical skills for waste disposal. This group of people are one of the key factors to the success of solid waste management. They can be the leader and good practices for the

communities. The community will get information and learn from people who had experience. It has study research found the knowledge gained from textbooks with those obtained from that practice may not match. It depends on the environment and may other causes when learn and take action both are completed that can be regarded as a teacher or exemplary (Minelgaite and Liobikiene, 2019).

Table 11 General information

Assessment lists	Frequency	Valid percent (%)
Gender		
Male	34	68.0
Female	16	32.0
Status		
Married	33	66.0
Single	16	32.0
other	1	2.0
Position		
Staff	49.0	98.0
Volunteer	1	2.0
Ages		
21-30 years	8	16.0
31-40 years	39	78.0
41-50 years	3	6.0
Education		
Bachelor’s degree	38	76.0
Master’s degree	12	24.0
Experience		
1-3 years	5	10.0
4-6 years	30	60.0
7-11 years	5	10.0
12-20 years	10	20.0

Table 12 Experience about solid waste management

Assessment list	Frequency	Valid percent (%)
Policymaker	16	32.0
Solid waste management (Coordinator)	4	8.0
Officer	29	58.0
Volunteer	1	2.0

1.3.2 knowledge and understanding of solid waste management

Table 13 showed the background of knowledge and understanding of DNRE staff towards solid waste management. It was found that 44.2% and 38.5% of total staffs from DNRE had recognized solid waste separation by bin types and solid waste management by composting. Interestingly, a little have understood about waste recovery (1.9%), sanitary landfill (3.8%) and 3Rs (5.8%). Moreover, less than 5% of DNRE staffs have recognized that open burning and open dumping were good practices for solid waste management. It related with their education and they have experiences worked with environmental. This result indicated that DNRE staff had more knowledge and understanding on solid waste management better than the villagers. However, more knowledge and professional training for waste to energy and waste to value added products may be required for the development of sustainable solid waste management in this area.

Table 13 The knowledge and understanding of solid waste management

Assessment lists	Frequency	Valid percent (%)
Sorted by bin types.	23	44.2
3R (Reduce, Reuse and Recycle)	3	5.8
Sanitary landfill	2	3.8
Waste recovery	1	1.9
Composting	20	38.5
Open dumping	2	3.8
Open burning	1	1.9
	52	100.0

1.3.3 Opinions on solid waste management, waste separation and 3Rs policy for solid waste management from DNRE

Table 14 shows that the highest score of the opinion on solid waste management is the strong agreement on the difficulty and complication of solid waste separation (4.92±0.34); it used to longtime and have not bins types. They also agreed on using reusable containers instead of plastic bags which could reduce the amount of general waste (4.64±0.56). High agreement score was also pointed out to the separation of food waste, vegetable and fruit peels before disposal into the wet bin (organic waste bin) with the mean value of 4.64±0.56. Although DNRE staff had the positive opinion towards waste separation and 3Rs (scored with the level 4 to level 5), there were still misunderstanding about several issues such as fundamental knowledge of plastic and its disposal, proper recycle waste handling and hazardous waste management (scored with the level 4 to level 5). Moreover, the DNRE staff also agree that solid waste separation is not the responsibility of the authorized person. It related with their knowledge and understanding about solid waste management. This also coincided with the result from the villager's opinions that waste separation should be done from its source or at household level. For this point policymaker should have a policy or campaign on the participation of everyone in each section about solid waste management.

Table 14 Knowledge and understanding of solid waste separation and 3Rs policy for solid waste management in DNRE

Like Scale: Level 1: Least agree, Level 2: Low agree, Level 3: Medium agree, Level 4: High agree and Level 5: Most agree

Assessment lists	Mean	Std. Deviation	Like Scales
1. Solid waste separation is difficult and complicate. However, it should be done to reduce environmental problems.	4.92	0.34	Most Agree.
2. Solid waste separation by types of bin types is time consuming.	4.10	0.84	High Agree
3. Solid waste management give the benefits to community.	4.62	0.60	Most Agree
4. The solid waste separation that is the good way to solve environment problems.	4.44	0.73	Most Agree
5. Food waste and water should be separated from recycle waste before dispose in the recycle bin.	4.54	0.58	Most Agree
6. Plastic bag and foam box can be naturally degraded in a short time.	3.62	1.45	High Agree
7. Solid waste such as food waste, Vegetable and fruit peels should be disposed in wet bin (organic waste bins)	4.64	0.56	Most Agree
8. Using reusable containers instead of plastic bags such as food containers, basket, cloths bags can reduce the amount of general waste.	4.64	0.56	Most Agree
9. Recycle waste such as paper (A4, carboard, books) are less value and cannot be recycle. It should be separated and disposed in the general bin (dry waste bins)	4.50	0.54	Most Agree

Assessment lists	Mean	Std. Deviation	Like Scales
10. Straws, coffee mugs, plastic, snack bags must be disposed in the general bin (dry waste bins)	4.70	0.54	Most Agree
11. Solid waste separation is the responsibility of the authorized person.	3.78	1.49	High Agree
12. Cause of the solid waste problems comes from the lacking of consciousness, awareness, and understanding.	4.60	0.53	Most Agree
13. Separating waste before disposal reduced the process of solid waste management.	4.60	0.53	Most Agree
14. Hazardous waste management used the same methods as general waste management.	4.22	0.86	Most Agree

Note: 1.00-1.80=Least agree, 1.81-2.60=Low agree, 2.61-3.40=Medium agree, 3.41-4.20=High agree and 4.21-5.00=Most agree.

1.3.4 The attitudes on solid waste management

The success of design and implementation of solid waste management policy and strategy, knowledge, participation (behaviors) attitudes and awareness are important key factors. The result found that all staff had the great attitudes towards solid waste management scored with level 5 (Table 15). They also had high willingness to separate solid waste at the workplace (mean 4.82±0.39) (Table 15). agreed that moreover, they also agreed that the government should provide training on solid waste management for officers (mean 4.80±0.64). From the result, it is a positive finding that all staff realized the important of solid waste management and had the willingness to solve this solid waste problem. This will be a good start for policy and strategic development.

This result were consistent with some studies that knowledge on solid waste management was related to the attitude and behavior of solid waste management. (Namjaitrong, 2018) mentioned that people behavior was related to the ability to remembering or to recall without complex thinking and it is a step to take Lead to behaviors and attitude.

Therefore, reskill and upskill of knowledge and practical on solid waste management for DNRE could be very useful. They can improve and develop their abilities and skills to teach and demonstrate people in the community. Learning from experienced people or authorized people had a lot of advantages on solid waste education, making it easier for people to understand and followed (Fernando, 2019). This could lead to better and effective solid waste management in the communities at Beung Kiat Ngong Ramsar site.

Table 15 The attitude on solid waste management

Like Scale: Level 1: Least agree, Level 2: Low agree, Level 3: Medium agree, Level 4: High agree and Level 5: Most agree

Assessment lists	Mean	Std. Deviation	Like Scales
1. You have a willingness to separate solid waste in your workplace.	4.82	0.39	Most Agree
2. You feel involved to solving solid waste problem and ready to make efforts to solve the problem.	4.74	0.44	Most Agree
3. You want to attend training on solid management whenever you can.	4.74	0.44	Most Agree
4. The government should provide training on solid waste management for DNRE's staffs.	4.80	0.64	Most Agree
5. You think that the solid waste problem is your responsivity.	4.62	0.72	Most Agree
6. DNRE should set of employee penalties when employees throw solid waste the wrong way.	4.56	0.67	Most Agree

Note: 1.00-1.80=Least agree, 1.81-2.60=Low agree, 2.61-3.40=Medium agree, 3.41-4.20=High agree and 4.21-5.00=Most agree.

1.3.5 The behavior about solid waste management

From the Tables 14 and 15, it was found that most staff had great knowledge and understanding on solid waste management, solid waste separation and 3Rs. They also had good attitudes on solid waste management. However, these results were quite contrast to their behaviors on solid waste management (Table 16). The result indicated that staff had moderate practice on waste separation and 3 Rs (mean3.16±1.53) for example, solid waste was rarely separated before disposal (mean 2.88±1.68) or less plastic was frequently reused (mean 2.88±1.67). They always accumulate trashes until it is too many to separate (mean 3.64±1.35). Moreover, they thought that the process of waste separation was inconvenience and time consuming (mean3.50±1.59). The factors that possibly affected their behaviors could be knowledge, beliefs, attitudes, attitudes values, motivation and determination to behave (Fan et al., 2019). From the results, building good attitude of staffs from department of natural resources and environment are very important because they are responsible for waste management. If staffs have a bad attitude about environment and solid waste management, it is unlikely that waste management system and practices and policy will not be success. We should take this more serious by emphasize on policies, incentives or punishments. It is apparent that there is the necessity to develop staffs' behaviors and willingness to reduce problems related to SWM. In addition, it should initially start from launching green policy in office such as green office or 3Rs and use environmentally friendly materials. In addition, Laos government should add the green policy about 3Rs or 5Rs in offices.

Table 16 The behavior related to solid waste management

Like Scale: Level 1: Least practiced, Level 2: Practiced at low, Level 3: Moderate, Level 4: High performed and Level 5: Most observed.

Assessment lists	Mean	Std. Deviation	Like scales
1. You always separate the solid waste before disposal.	2.88	1.68	Moderate
2. You always separate and collect organic waste for animal feeding and composting.	3.14	1.66	Moderate
3. You always reuse plastic bags.	2.88	1.67	Moderate
4. Once litters are not in the trash bin, you will not collect it and throw into the bin.	3.58	1.41	High Performed
5. If there is no trash bin in your area, you will leave the solid waste there for the housekeeper to collect.	3.46	1.62	High Performed
6. You often handles solid waste by onsite accumulation without separation until they become too many to do.	3.64	1.35	High Performed
7. You always wash the plastic bags and foam before throwing into the bin.	2.86	1.65	Moderate
8. You separate all types of solid waste, except the one that is contaminated with food waste.	2.88	1.49	Moderate
9. You do not separate waste before throwing into the bin because of inconvenience and time consuming.	3.50	1.59	High Performed

Assessment lists	Mean	Std. Deviation	Like scales
10. You always look for the recycle symbols on the plastic products before making decision.	2.88	1.29	Moderate
11. You always reuse the trash that is still usable.	3.02	1.35	Moderate
12. Once you have found the bin that is full, you still throw the trash into that bin.	3.18	1.64	Moderate

Note: 1.00- 1.80=Least practiced, 1.81-2.60=Practiced at low, 2.61-3.40=Moderate, 3.41-4.20=High performed and 4.21-5.00=Most observed.

2. Feasibility study on the production of value -added from golden apple snail shells (GAS)

The resulted from the survey and resulted from questionnaires (the detail as above) both villages in BKN Ramsar site; they were farmer and had education at Elementary level. BKN Ramsar site had open dumpling and open burning in public areas. Collection of golden apple snails for sale has become popular among farmers to earn extra income after the end of rice plantation period. It had organic wastes that opened dumpling in public areas about 90% of total. Once the golden apple snail shells were washed, they were then boiled and their shells were removed. Only their meat was sold in the local market and the Pakse market. The price for 1 kg of snail meat costs approximately 6,000 to 10,000 kip (30 to 50 baht). Recently, it seems that the demand of this exotic golden apple snail meat has been increasing which means that higher amount of its shells has also been rising.

However, it was mentioned earlier that large amount of golden apple snail shells were open dumped and scattered everywhere in the public area of both villages. Also, it took quite a long time for shells to be naturally degraded due to its rigid structure. Improper management of these shells can cause problem in the future. For the sake of sustainable development of wetland area, a better management of these shell waste is required. In this work, the idea of transform this shell waste into value added product; calcium carbonate ($CaCO_3$), was proposed. This could help the communities to well manage of the shells waste and also to give the benefits in terms of getting extra income or using for agriculture. However, the method that can be easily applied to local community such as Thapou village and Kiat Ngong village should be considered.

In this work, incineration process was selected as one of possible solutions for both communities. This method used for organic substances removal that contained on the surface of the shells. Some research found that incineration could increase the purity of $CaCO_3$ from shells. Using higher temperature could reduce $CaCO_3$ concentration due to changing of $CaCO_3$ to calcium oxide (CaO) (Boonyuen, 2016);

(Rungpin, 2011). In order to get high amount of calcium carbonate from golden apple snail shells, moreover, the efficiency of the selected method was identified. Also, the parameter such as temperature that affected the quality of obtained calcium carbonate was studied. The results are explained below

2.1. Effect of temperature on $CaCO_3$ production from golden apple snail shells (GAS)

In nature, many materials have been found with the main composition of calcium carbonate such as coral, egg shells and shells. It can be up to 95% -99% by weight and only 0.1% -5.0% by weight is protein bonding agents (Rungpin, 2011). The shell also has a seal layer made of calcium (prismatic layer), which is a strong layer. Most of them contain high proportion of the calcium compounds in the form of calcite (Boonyuen, 2016). Some findings found that the quality and quantity of Ca and $CaCO_3$ obtained from shells are comparative with temperatures. By testing with temperatures in the range of 500°C to 900°C, it was found that $CaCO_3$ could be obtained at lower temperatures, while higher temperatures changed form of $CaCO_3$ to calcium oxide (Boonyuen, 2016); (Rungpin, 2011). In this work, the incineration process was used to get $CaCO_3$ from golden apple snail shells (GAS) and the incineration temperature were varied between 400°C, 500°C and 600°C. For each temperature, three treatments of that were (A) crushed before incineration (B) Incineration without crushing and (C) Control with no incineration and no crushing were conducted in triplicate. Table 17 showed the amount of biomass, % yield and $CaCO_3$ obtained from GAS between treatments. It was found that there was no significant different of GAS biomass and % yield obtained between treatment A and treatment B and between temperatures (400°C, 500°C and 600°C) (ANOVA; $P>0.05$). Yield percentages obtained from both treatment A and B were found in the range between 93-95%. Highest % yield with the value of 95.93±0.19% and 96.92±0.75% was found from incineration temperature at 500°C and 400°C for treatment A and treatment B, respectively.

However, the results EDTA determination showed significant different between $CaCO_3$ obtained from treatments A, B and control (ANOVA; $P=0.006$). It was

found that highest amount of $CaCO_3$ obtained from treatment B after incinerated at 400°C with the value of 624.00±4.00 mg/L as $CaCO_3$), while lower amount of $CaCO_3$ found at higher temperature (Table 17 and Figure 19. This also happened for treatment A where higher temperature showed lower amount of $CaCO_3$. As can be seen from Figure 19, it is clear that incineration at 600°C gave lowest amount of $CaCO_3$ for both treatments. This is consistent with previous research that higher temperature reduces the amount of $CaCO_3$ due to the decay from calcium carbonate ($CaCO_3$) to calcium oxide (CaO) (Boonyuen, 2016). Incineration at high temperature can reduce weight, shell color and other chemical composition in the shells. Moreover, the findings indicated that the method of crushing before incineration (A) provided less amount of $CaCO_3$ than incineration without crushing (B) and no incineration and no crushing (C). This could be the result of the surface of the GAS is thoroughly heated when incineration and changed become ashes.

Table 17 Biomass, % yield and $CaCO_3$ obtained from GAS shell

Treatments	Incineration temperature	Amount (g) Before incineration	Amount (g) After incineration	% Yield	$CaCO_3$ by EDTA (mg/L as $CaCO_3$)
A	400 °C	201.48±0.31	193.23±0.97	95.90±0.49[a]	158.00±2.00[b]
	500 °C	200.90±0.46	192.73±0.55	95.93±0.19[a]	158.00±2.00[b]
	600 °C	200.58±0.25	192.37±0.05	95.91±0.12[a]	74.67±18.90[b]
B	400 °C	201.08±0.27	194.89±1.41	96.92±0.75[a]	624.00±4.00[a]
	500 °C	201.21±0.49	190.63±1.08	94.74±0.76[a]	392.00±8.00[a]
	600 °C	201.93±0.21	188.18±4.60	93.19±2.37[a]	61.33±20.13[a]
Control					12.17±0.23[b]

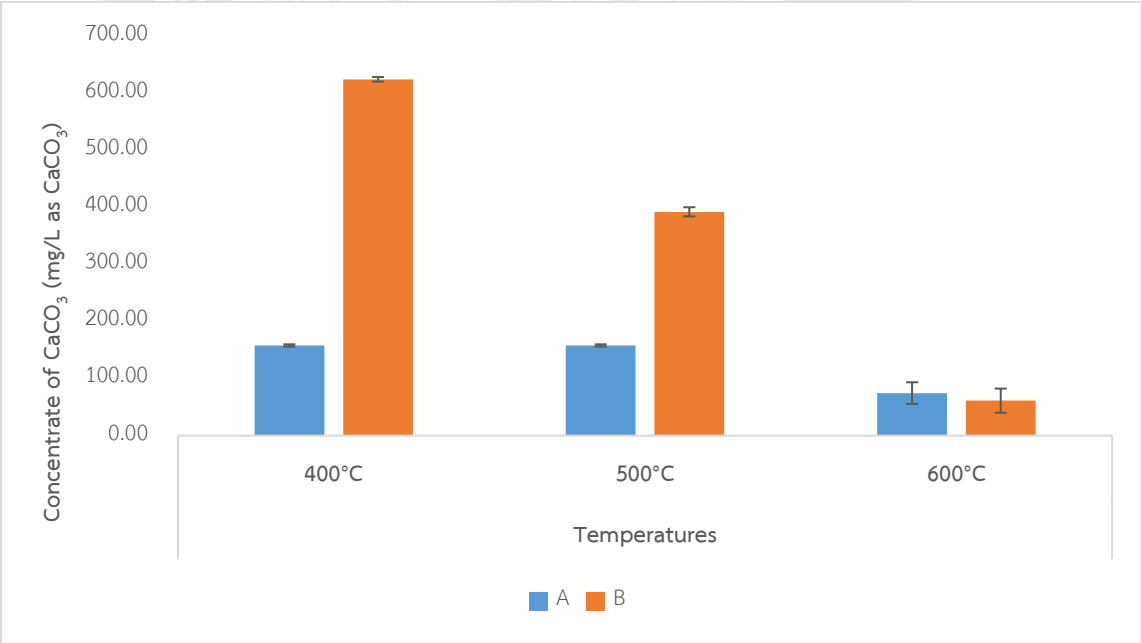


Figure 19 Average concentration of $CaCO_3$ obtained from GAS between2 treatments (A) crushed before incineration, (B) incineration without crushing

In order to determine the composition of calcium ion or others elements, however, atomic absorption spectrophotometry (AAS) has been reported to be more rapid and accurate than the EDTA which mostly relied on titration

technique. To confirm the results of $CaCO_3$ concentration obtained from GAS shells, AAS method was performed to determine the amount of Ca^+ and convert to $CaCO_3$. The results indicated that the value of $CaCO_3$ obtained by atomic absorption determination were smaller than those obtained by EDTA titration. The amounts of $CaCO_3$ using EDTA-titration were consistently higher than AAS due to the reverse chemical reaction between $CaCO_3$ and CaO. As samples of GAS powders were stored over a long period of time before detection by AAS, the conversion from $CaCO_3$ to CaO has occurred (Boonyuen, 2016). However, similar trend of decreasing of $CaCO_3$ along with higher temperature was detected from both techniques. The results showed that incineration at the low temperature B400℃ gave the highest amount of $CaCO_3$ (624.00mg/L as $CaCO_3$ from EDAT method and 64.65 mg/L as $CaCO_3$ from AAS method). Even though, organic substance is removed and $CaCO_3$ can convert to CaO when the temperature is rising, but higher ash can be obtained.

Table 18 The comparison of $CaCO_3$ concentration obtained from GAS between EDAT method and AAS method

Samples	Weight (g)	EDTA (mg/L as $CaCO_3$)	AAS (mg/L as $CaCO_3$)
Control	0.1	12.17	7.96
A(400°C)	0.1	158.00	34.71
A(500°C)	0.1	158.00	31.47
A(600°C)	0.1	74.67	9.31
B(400°C)	0.1	624.00	64.65
B(500°C)	0.1	392.00	32.29
B(600°C)	0.1	61.33	29.44

Physical characterization (color and softness) of GAS powder sample are presented in Table 19 and Figure 20. The results showed that the color of GAS powder of treatment A was white grey, while the one from treatment B showed brown color. However, the color of GAS powder obtained at the highest temperature from both treatments turned to be ashy color. The texture of $CaCO_3$ powder obtained after incineration treatments (A and B) was also softer than the fresh shells. This may have resulted from changing morphology and phase composition of calcined GAS.

Table 19 Physical characterization of GAS shell

Number	Temperature (°C)	Time(hr)	Physical characterization	
			Color	Softness
Raw shell	Room temperature	-	Gray brown	Hard, Flake
A1	400	1	White Gray	Soft, powder
A2	500	1	White Gray	Soft, powder
A3	600	1	Ashy	Powder
B1	400	1	Brown	Soft, powder
B2	500	1	Brown	Soft, powder
B3	600	1	Ashy	Powder

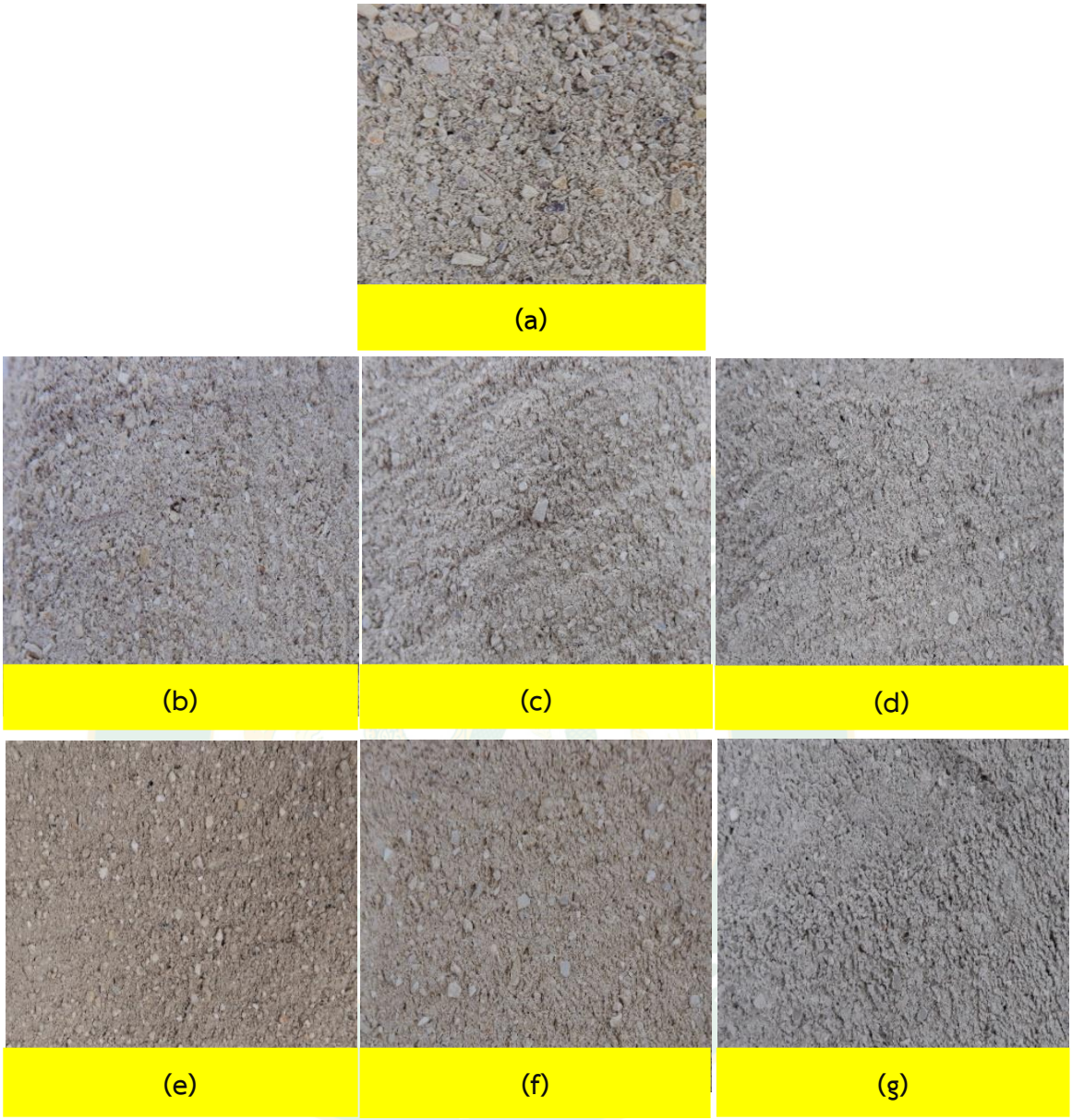
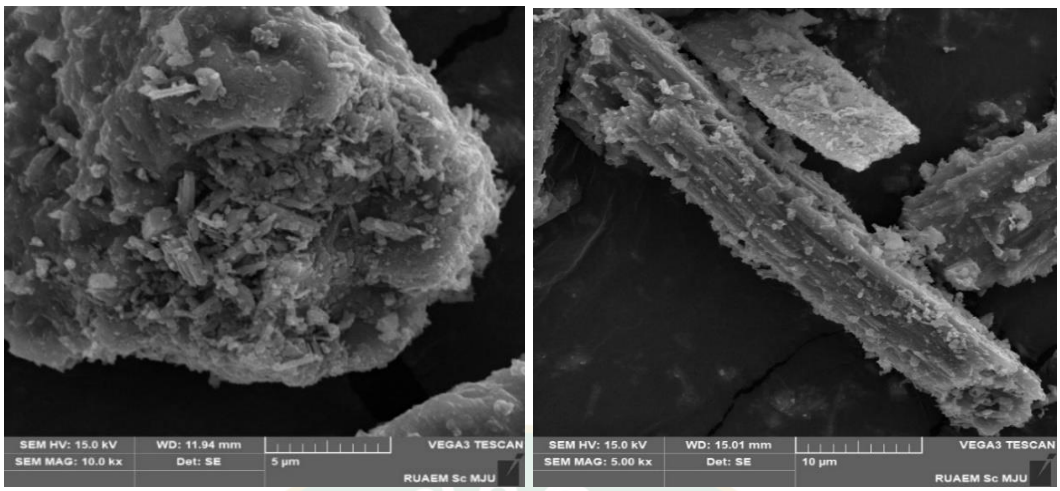


Figure 20 GAS shell after crushed into powders: a.) Control, b.) A400°C, c.) A500°C, d.) A600°C, e.) B400°C and f.) B500°C and g.). B600°C

Surface morphology of incinerated GAS at B400°C and control were observed under Scanning Electron Microscopy (SEM). The results are shown in Figure 21. From these observations, it was found that various pore sizes occurred on the surface of GAS and $CaCO_3$ crystal structure was observed. However, surface morphology changed after GAS was incinerated due to the removal of the water and organic materials from GAS (Figure 21). Normally, the morphology of calcium carbonate can

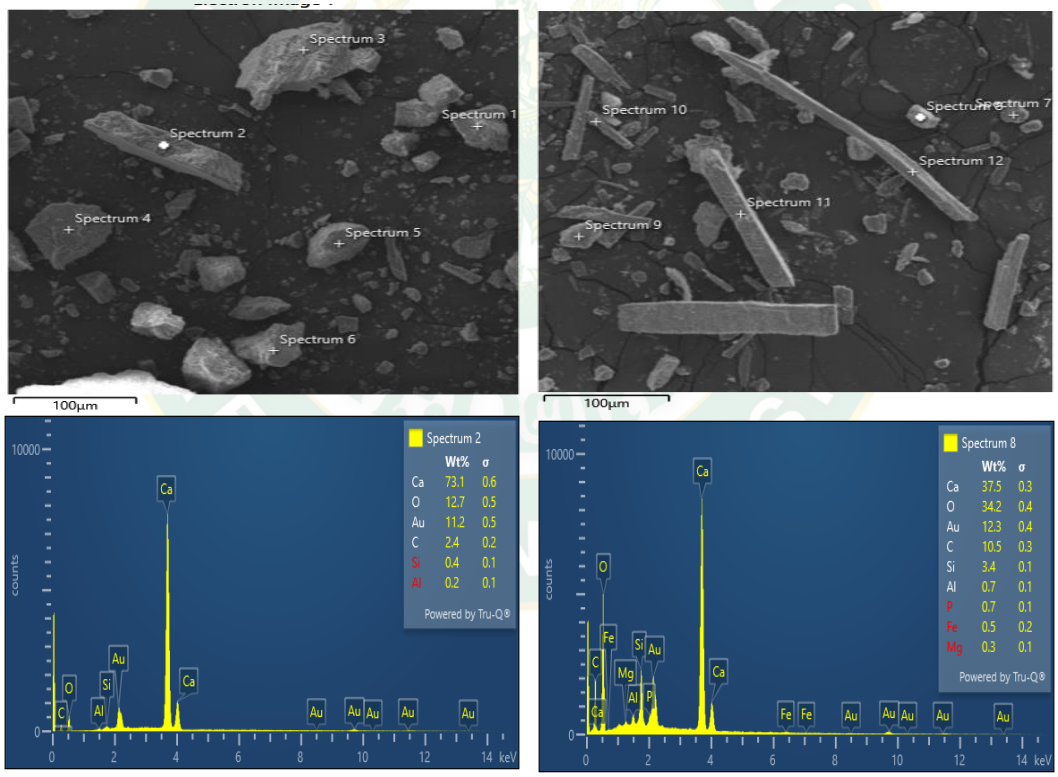
be in either rod shape and cuboid shape with the distribution of both large and small particle sizes. This is due to the crystallization behavior of calcium carbonate (Patta, Hawae et al., 2015).

Figure 22 displays the composition of GAS obtained from treatment B incinerated at 400°C, where highest $CaCO_3$ has been observed. The results of SEM between both spectrum samples showed highest proportion of Ca found in GAS (Figure 22). However, the ratio between Ca, C and O were different between both spectrum samples. This may be the result of oxidation process during incineration. Moreover, only 0.4% Silicon and 0.2% Aluminum was found from spectrum 2 and 3.4% Silicon, 0.7% Aluminum, 0.5% Iron and 0.3% Magnesium found from spectrum 8. This result suggested that less heavy metal component was found from incinerated GAS which was less than 3 ppm; the ASTM standard (Laonapakul, 2014). The results revealed that golden snail shells waste can be changed into $CaCO_3$ as value-added product with some trace elements that can be used in the local community.



(a) (b)

Figure 21 Scanning Electron Microscopy (SEM) of GAS treatment B400°C



(a) (b)

Figure 22 SEM - EDS of incinerated GAS from Treatment B at 400°C: a.) spectrum no 2 and b.) spectrum no 8

3. Strategic plans for sustainable solid waste management in Beung Kiat Ngong Ramsar site

From the survey and questionnaires responses results (both villages and DNRE), it was found that the majority of the population from both villages were farmers who mainly engage in paddy rice cultivation. Women were the majority of responses in the villages, while men were dominant in DNRE. It appeared that villagers lack of knowledge and understanding of solid waste separation and 3Rs, but still have some behavior and practice concerning solid waste management. The resulted also showed that DNRE were officers and policymakers who had experiences on solid waste management as well as knowledge and understanding about 3Rs. However, more knowledge and professional training on waste to energy and waste to value added products such as GAS to $CaCO_3$ or other products from waste would be useful. These information will be used as the guideline for strategic plans aiming to sustainable solid waste management in Beung Kiat Ngong Ramsar site.

The possible strategic plans for sustainable solid waste management in Beung Kiat Ngong Ramsar site was suggested. Currently, it is obvious that there was no separation of compostable or organic waste and recycle waste from general wastes generated from households. All waste has been dumped to the public areas and local landfills, while open burning was always occurred. Lacking of proper solid waste management practices such as waste collecting and 3Rs as well as knowledge and understanding was also observed in both areas. Based on the information obtained above, the strategy that should be started for the villagers is education. Then the practical training on waste separation and collection, reduce, reuse and recycle are required. Besides, the knowledge and application of value-added products from waste should be promoted. Moreover, the authorities or the government officers should be reskilled, upskilled and trained in the topics related to solid waste management. Then the campaign and activities related to solid waste management should be launched and promoted to the communities. Great participation between people from the communities and the authorities is another important key factor for

the success of solid waste management. Effective communications between two sectors are indispensable. This can be achieved by being good example or giving best practices for communities. Therefore, awareness and behaviors need to be raised in the office. Changing the personal attitudes and behaviors is challenging. However, the strategic plan should be developed according to the context of community and nature of people. From the study, the strategy plan for Thabou village and Kait Ngong village are shown in Figure 23 and Figure 24.

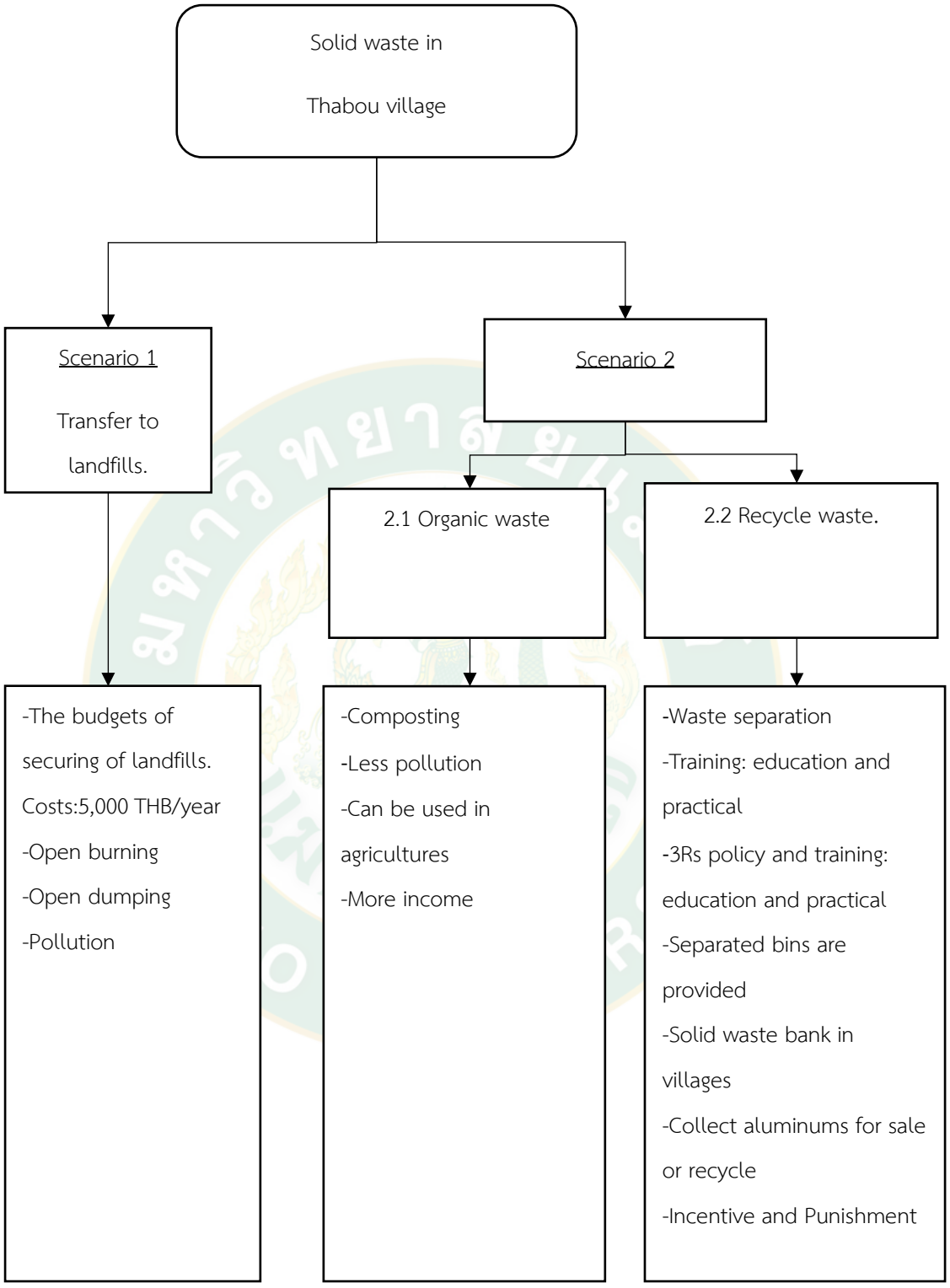


Figure 23 Strategy of converting solid waste into value at Thabou village

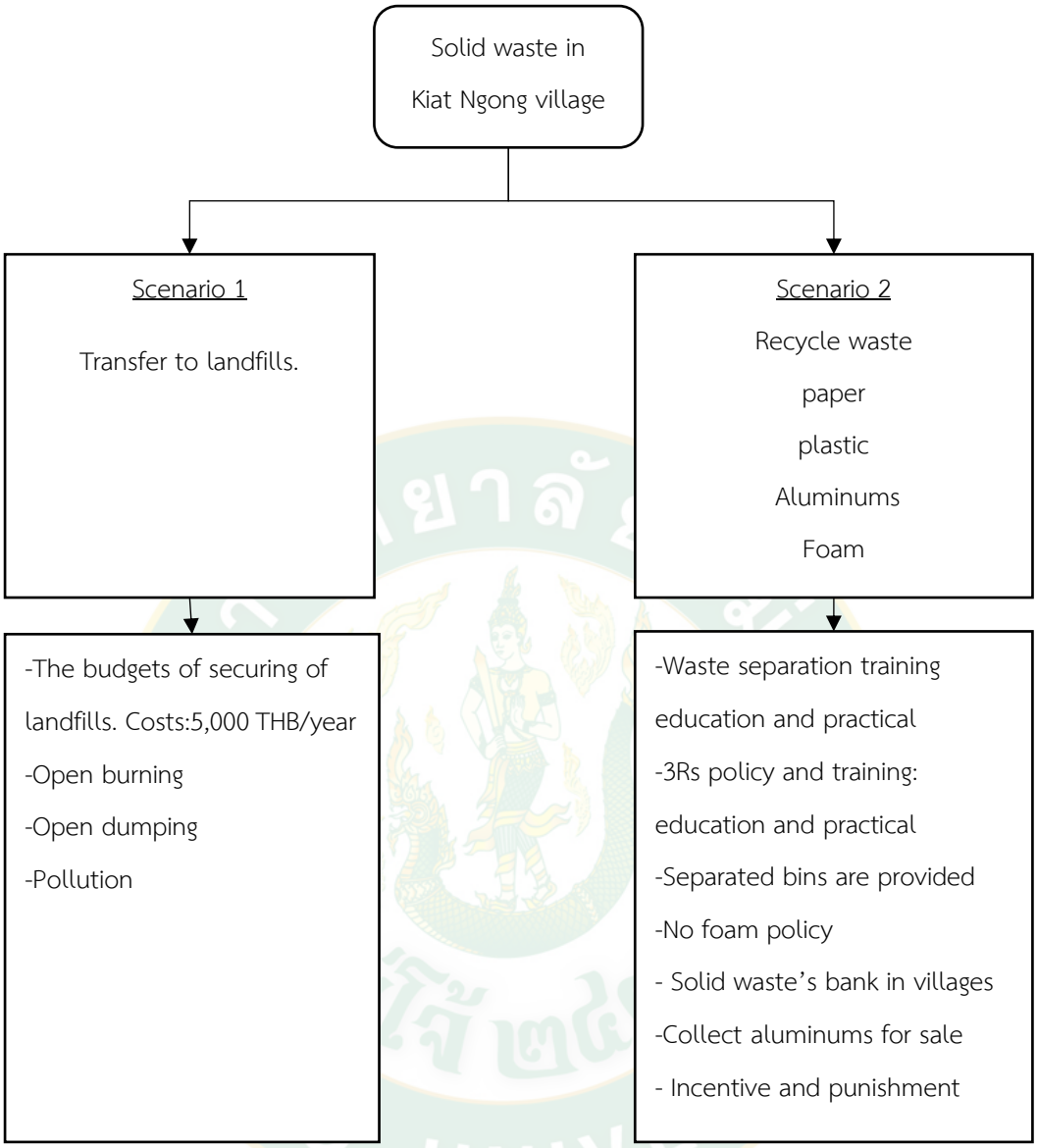


Figure 24 Strategy of converting solid waste into value at Kiat Ngong village

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 source of waste 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. Rules and regulations about solid waste management should be set and act. Incentive and legal punishment should be one of the top lists. 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 (Figure 25). Every year GAS has been 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 bath/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 (Bank, 2020). Interestingly, adding the values into GAS by converting into $CaCO_3$ using as a replacement from bones or limestone could be the alternative solution for this waste. Not only GAS waste will be well managed, but the communities can also gain benefits from it. Approximately 98,549 kg/year of GAS produced up to 30,747 kg of $CaCO_3$. It can be used for many industrial production processes and agricultural sectors. Calcium carbonate from GAS was reported to be used as dietary supplement for Japanese quail production (Petchpankan, 2010). For raising 500 units of Japanese quail, using 15 Kg of $CaCO_3$ produced from GAS could reduce the operation cost at least 6,000 THB per day.

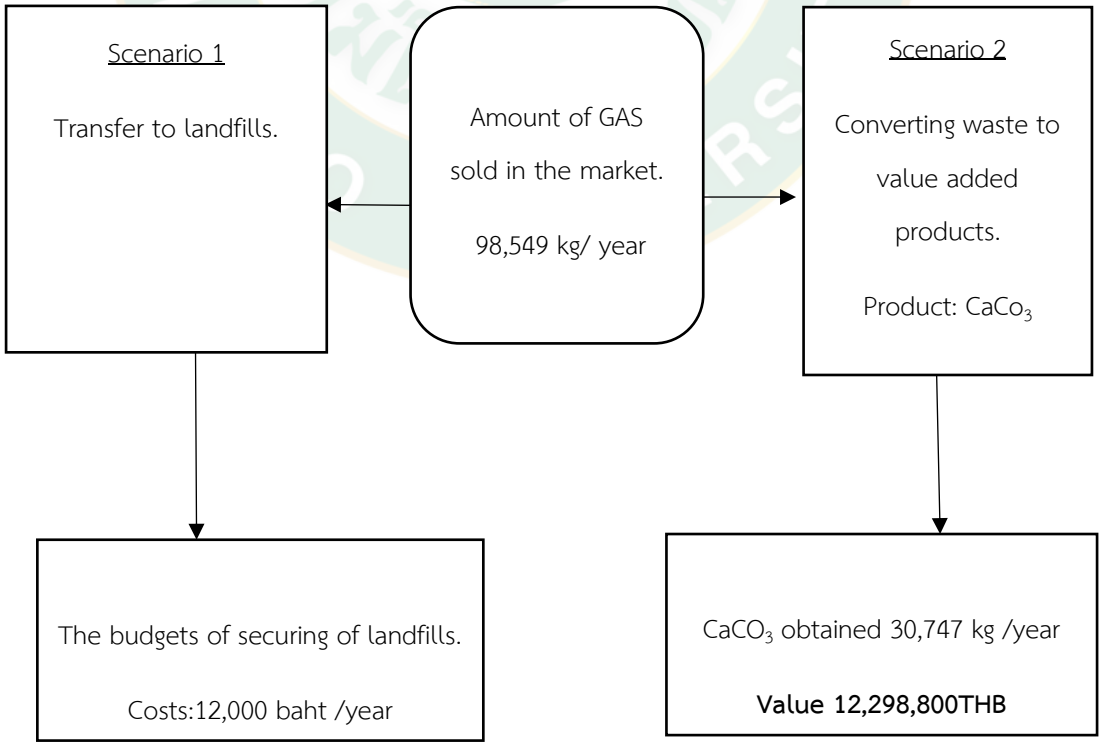


Figure 25 Strategy of converting GAS shell into value $CaCO_3$

CHAPTER 5

CONCLUSION

This work highlighted possible solid waste strategy that could be applied in BKN Ramsar site, Pathoumphone district, Champasack province, Laos PDR. The result indicated that composition of solid waste varied between sites and locations, income, and activities from two villages. However, the findings of this work are as followed;

1. Thabou village, as a representative of agriculture area, generated highest proportion of organic waste (Yard waste), while majority of waste in Kiat Ngong village, as tourist site representative, were packaging such as plastic and foam.

2. Both villages still lacked of knowledge and understanding of solid waste separation and 3Rs. However, the result showed that more activities on solid waste separation and 3Rs found from Thabou village than Kiat Ngong village.

3. It was also found that Thabou village had better attitude and behavior towards solid waste management.

4. People in both villages did not have a well-managed of golden snail shells waste.

From all information, the recommendation of strategic policy framework in both villages are education, raising community awareness, participation. The topics that should be implemented in the areas are 3Rs (reduce, reuse and recycling), composting, solid waste's bank and value-added production.

5. It was found that DNRE staff had more knowledge and understanding on solid waste management and all staff had the great attitudes toward solid waste management. However, more knowledge and professional training for waste to energy and waste to value added products may be required for the development of sustainable solid waste management.

6. For policy recommendations, the government should allocate a budget to purchase vehicles to collect solid waste from the village-to-village landfills and increase the number of bins.

7. The government should conduct a training program on the knowledge of solid waste separation, composting and bio-compost and 3Rs for the people in BKN Ramsar site.

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.

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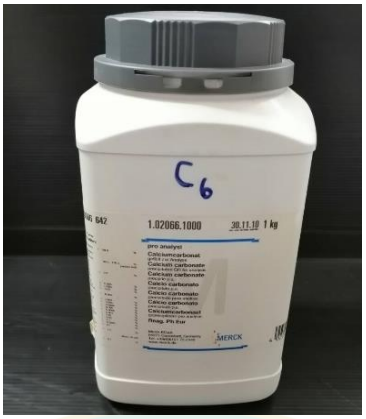
Appendix

Appendix A. Figures.

Figures 1 The sampling process (Quartering method)

Figures 2 experimental of the moistures of solid waste.

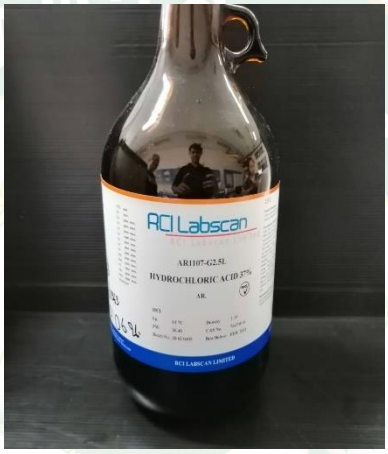
a.



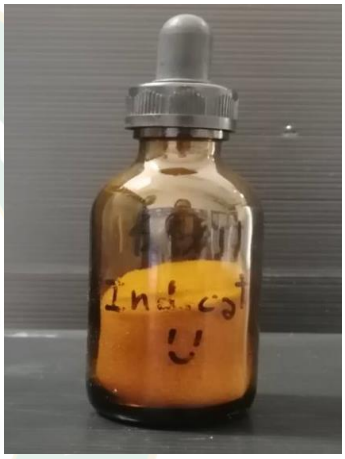
b.

c.

d.



e.



f.

Figures 3 of chemicals: a.) Sodium Chloride 99%(Nacl), b.) Calcium Carbonate ($CaCO_3$), c.) Murexide, d. Sodium Hydroxide 97%(NaOH), e.) Hydrochloric Acid 37%(HCL), f.) Indicator.

a. b.

Figures 4 of equipment's experimental: a.) Incineration b.) Analytical Balance.

a. b.

Figures 5 Golden Apple snail shells: a.) Before incineration and b.) after incineration.

Figures 6 Atomic Absorption Spectroscopy (AAS) method.

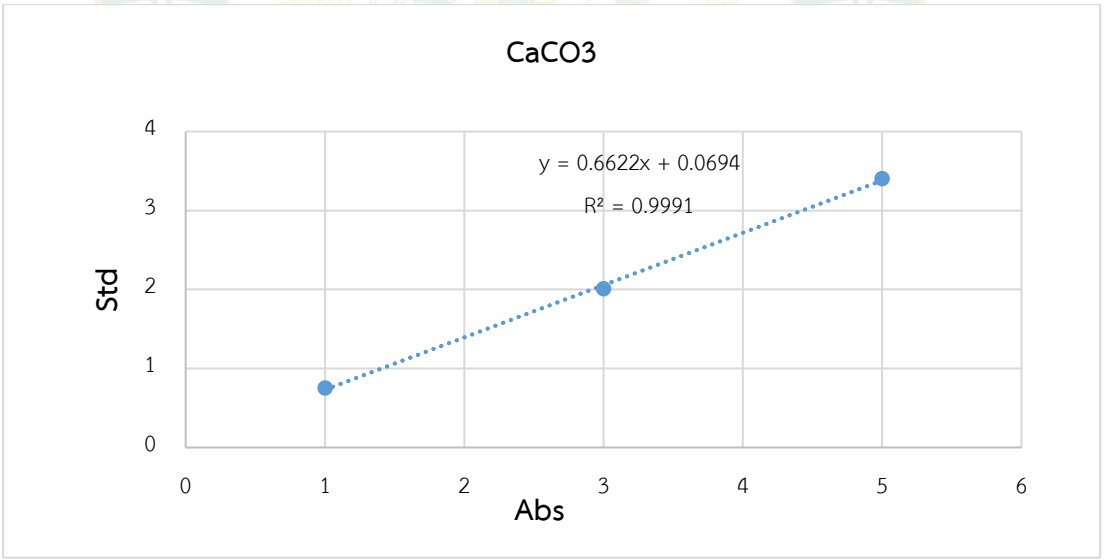


Figure 7 standard chart

Appendix B. Tables.

B. Table. Calculation for $CaCO_3$ by EDTA

Table1 Treatment C control

Control	Weight of GAS powers(g)	Weight of GAS powders(g)use	$CaCO_3$ mg/l as $CaCO_3$
C1	198.7922	0.10	12.32
C2	198.4271	0.10	11.90
C3	198.3450	0.10	12.29
Total			12.17

Table2 A: Crushed before incineration (A1:400°C)

Samples	Weight of GAS powders(g) (400°C)	Weight of GAS powders(g)use	Calcium Carbonate ($CaCO_3$) mg/l as $CaCO_3$
A1.1	192.86	0.10	160.00
A1.2	192.02	0.10	156.00
A1.3	194.06	0.10	158.00
Total			158.00

Table 3 A: Crushed before incineration (A2:500°C)

Samples	Weight of GAS powders(g) (500°C)	Weight of GAS powders(g)use	Calcium Carbonate ($CaCO_3$) mg/l as $CaCO_3$
A2.1	191.99	0.10	158.00
A2.2	193.02	0.10	156.00
A2.3	192.48	0.10	160.00
Total			158.00

Table4 A: Crushed before incineration (A3: 600°C)

Samples	Weight of GAS powders(g) (600°C)	Weight of GAS powders(g)use	Calcium Carbonate ($CaCO_3$) mg/l as $CaCO_3$
A3.1	192.10	0.10	68.00
A3.2	191.69	0.10	60.00
A3.3	191.78	0.10	96.00
Total			74.67

Table5 B: Incineration without crushing (B1: 400°C)

Samples	Weight of GAS powders(g) (400°C)	Weight of GAS powders(g)use	Calcium Carbonate ($CaCO_3$) mg/l as $CaCO_3$
B1.1	193.49	0.10	620.00
B1.2	193.15	0.10	624.00
B1.3	193.97	0.10	628.00
Total			624.00

Table 6 B: Incineration without crushing (B2: 500°C)

Samples	Weight of GAS powders(g) (500°C)	Weight of GAS powders(g)use	Calcium Carbonate ($CaCO_3$) mg/l as $CaCO_3$
B2.1	189.50	0.10	400.00
B2.2	191.36	0.10	384.00
B2.3	189.49	0.10	392.00
Total			392.00

Table7 B: Incineration without crushing (B3: 600°C)

Samples	Weight of GAS powders(g) (600°C)	Weight of GAS powders(g)use	Calcium Carbonate ($CaCO_3$) mg/l as $CaCO_3$
B3.1	182.62	0.10	64.00
B3.2	187.79	0.10	40.00
B3.3	192.39	0.10	80.00
Total			61.33

Table 8 The standard and absorbance (Abs).

Standard (Std)	Absorbance (Abs)
1	0.7566
3	1.9453
5	3.6580

Appendix C. Questionnaires.

Appendix C. Questionnaire1 for the department of natural resources and environment in Champasack province, Laos PDR.

Questionnaire

For Community based solid waste management at Ramsar site of the Laos PDR.

A case study of Beung Kiat Ngong Ramsar Site.

1. The purpose of this questionnaire is to use the results as a guideline for determining the efficiency of community based solid waste management at Ramsar site of the Laos PDR. A case study of Beung Kiat Ngong Ramsar site. Place a tick **✓** in the space that best describes your information.

2. The respondents consisted of staffs from the department of natural resources and environment in Champasack province, Laos PDR.

3. The research hereby certifies that all information provided by you will be helpful in applying as a guideline for the management of community based solid waste management at Ramsar site of the Laos PDR. A cause study of Beung Kiat Ngong Ransar site. The presentation of the information that has been received will be presented which does not affect your status in anyway.

The questionnaire consists of

Part 1: General information of respondents

Part2: the questions about knowledge and understanding of solid waste management.

Part3: the questions about attitude on solid waste management.

Part4: the question about behavior on solid waste management.

Evaluation criteria

Level 1 Least agree level 2 Low agree.

Level 3 Medium agree Level 4 High agree

Level 5 Most agree.

When you complete very questionnaire and all questions have been complete pleased send the questionnaire back to the researcher. For the researcher

to continue analyzing the data. The researcher would like to thank everyone for completing all parts of this questionnaire.

Miss Thiddavanh KHAMKEO

Email: Thiddavanhkhamkeo@gmail.com

Major: Environmental technology

Faculty of science

Maejo university

Part1: General information of respondents.

1. Sex

☐ Male ☐ Female

2. Status

☐ Married ☐ Single ☐ Divorced ☐ Other .....

3. Position

☐ Head of staff ☐ Staffs ☐ Volunteer

4. Age

☐ <20 Years ☐ 21-30 Years ☐ 31-40 Years ☐ 41-50 Years ☐ 51-60 Years

5. Education

☐ High school/Vocational ☐ bachelor's degree ☐ master's degree ☐ Doctor degree

6. Experience

☐ <1Years ☐ 1-3Years ☐ 4-6 Years ☐ 7-11 Years ☐ 12-20 Years ☐ 21 Years or more

7. Experience in waste management

☐ Policymaker

☐ Solid waste management (Coordinator)

☐ Officer

☐ Others

.....

(Please specify)

☐ It was never involved in any solid waste management process.

8. Knowledge and understanding of solid waste management (Can answer more than 1 question)

☐ Sorting by bin types

☐ 3 R (Reuse Recycle and Reduce)

☐ Local landfill

☐ Waste recovery

☐ composting

☐ Open dumping.

☐ Open burning

Part2: the questions about knowledge and understanding of solid waste management. (Level1: least agree, Level 2: Low agree, Level 3: Agree medium, Level 4: High agree, Level 5: Most agree)

Assessment list	Rating Level				
	5	4	3	2	1
1. Solid waste separation is difficult and complicate. However, it should be done to reduce environmental problems.					
2. Solid waste separation by types of bin type is time consuming.					
3.Solid waste management give the benefit to community.					
4. The solid waste separation that is the good					

way to solve environmental problems.					
5. Food waste and water should be separated from recycle waste before dispose.					
6. Plastic bag and foam can be naturally degraded in a short time.					
7. Solid waste such as food waste, Vegetable and fruit peels should be disposed in wet bin (organic waste bins)					
8. Using reusable containers instead of plastic bags such as food containers, basket, cloth bags can reduce the amount of general waste.					
9. Recycle waste such as paper (A4, cardboard, books) are less value and cannot be recycle. It should be separated and disposed in the general bin (dry waste bins).					
10. Straws, coffee mugs, plastic, snack bags must be disposed in general bin (dry waste bins).					
11. Solid waste separation is the responsibility of the authorized person such as local municipality.					
12. cause of the solid waste problems comes from the lacking of consciousness, awareness, and understanding.					
13. Waste Separation before disposal reduced process of solid waste management.					
14. Hazardous waste management used the same methods as general waste management.					

Part3 the questions about attitude on solid waste management (Level1: Least agree, Level2: Low agree, Level3: medium agree, Level4: high agree, level5: most agree)

Assessment list	Rating Level				
	5	4	3	2	1
1. You have a willingness to separate solid waste in your workplace.					
2. You feel involved to solving solid waste problem and ready to make efforts to solve the problem.					
3. You want to attend training on solid waste management whenever you can.					
4. The government should provide training on solid waste management for DNRE's staffs.					
5. You think that solid waste problem is your responsibility					
6.Department of Natural Resources and Environment Champasack province, Lao PDR, should set of employee penalties when employees throw solid waste the wrong way.					

Part4 the question about behavior on solid waste management (Level1: least practiced, Level2: practiced at low, Level3: moderate, Level4: high performed, Level5: most observed)

Assessment list	Rating Level				
	1	2	3	4	5
1. You always separate the solid waste before disposal.					
2. You always separate and collect organic waste for animal feeding and composting.					
3. You always reuse plastic bags.					
4. Once litters are not in the trash bin, you will not collect it and throw into the bin.					

5. If there is not trash bin in your area you, you will leave the solid waste there for the housekeeper to collect.					
6. You often handles solid waste by onsite accumulation without separation until they become too many to do.					
7. You always wash the plastic bag and foam before throwing into the bin.					
8. You separate all types of solid waste, except the one that is contaminated with food waste.					
9. You do not separate waste before throwing into the bin because of inconvenience and time consuming.					
10. You always look for the recycle symbols on the plastic products before making decision.					
11. You always reuse the trash that is still usable.					
12. Once you have found the bin that is full, you still throw the trash into that bin.					

Recommendations on solid waste management

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Appendix C. Questionnaire2 for villages in Beung Kiat Ngong Ramsar Site.

Questionnaire

For Community based solid waste management at Ramsar site of the Laos PDR.

A case study of Beung Kiat Ngong Ramsar Site.

1. The purpose of this questionnaire is to use the results as a guideline for determining the efficiency of community based solid waste management at Ramsar site of the Laos PDR. A case study of Beung Kiat Ngong Ramsar site. Place a tick **√** in the space that best describes your information.

2. The respondents consisted of people in two villages; Thabou village and Kiat Ngong village in Beung Kiat Ramsar site, Pathoumphone district, Champasack province, Lao PDR.

3. The research hereby certifies that all information provided by you will be helpful in applying as a guideline for the management of community based solid waste management at Ramsar site of the Laos PDR. A cause study of Beung Kiat Ngong Ransar site. The presentation of the information that has been received will be presented which does not affect your status in anyway.

The questionnaire consists of

Part 1: General information of respondents

Part2: the questions about knowledge and understanding of solid waste management.

Part3: the questions about attitude on solid waste management.

Part4: the question about behavior on solid waste management.

Evaluation criteria

Level 1 Least agree level 2 Low agree.

Level 3 Medium agree Level 4 High agree

Level 5 Most agree.

When you complete very questionnaire and all questions have been complete pleased send the questionnaire back to the researcher. For the researcher

to continue analyzing the data. The researcher would like to thank everyone for completing all parts of this questionnaire.

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Part1: General information of respondents.

1. Sex

☐ Male ☐ Female

2. Status

☐ Married ☐ Single ☐ Divorced ☐ Other .....

3. Age

☐ <20 Years ☐ 21-30 Years ☐ 31-40 Years ☐ 41-50 Years
☐ 51-60 Years

4. Education

☐ Lower than elementary ☐ Elementary ☐ High school/
☐ Vocational Bachelor's degree

5. Knowledge and understanding of solid waste management (Can answer more than 1 question)

☐ Sorting by bin types ☐ Open dumping
☐ 3 R (Reuse Recycle and Reduce)
☐ Local landfill ☐ Open burning
☐ Waste recovery
☐ Composting

Part2: the questions about knowledge and understanding of solid waste management. (Level1: least agree, Level 2: Low agree, Level 3: Agree medium, Level 4: Highly agree, Level 5: Most agree)

Assessment list	Rating Level				
	5	4	3	2	1
1. Solid waste separation is difficult and complicate. However, it should be done to reduce environmental problems.					
2. Solid waste separation by types of bin type is time consuming.					
3.Solid waste management give the benefit to community.					
4. The solid waste separation that is the good way to solve environmental problems.					
5. Food waste and water should be separated from recycle waste before dispose in the recycle bin.					
6. Plastic bag and foam can be naturally degraded in a short time.					
7. Solid waste such as food waste, Vegetable and fruit peels should be disposed in wet bin (organic waste bins)					
8. Using reusable containers instead of plastic bags such as food containers, basket, cloth bags can reduce the amount of general waste.					
9. Recycle waste such as paper (A4, cardboard, books) are less value and cannot be recycle. It should be separated and disposed in the general bin (dry waste bins).					
10. Straws, coffee mugs, plastic, snack bags must					

be disposed in general bin (dry waste bins).					
11. Solid waste separation is the responsibility of the authorized person such as local municipality.					
12. cause of the solid waste problems comes from the lacking of consciousness, awareness, and understanding.					
13. Waste Separation before disposal reduced process of solid waste management.					
14. Hazardous waste management used the same methods as general waste management.					

Part3 the questions about attitude on solid waste management (Level1: Least agree, Level2: Low agree, Level3: medium agree, Level4: high agree, level5: most agree)

Assessment list	Rating Level				
	5	4	3	2	1
1. You have a willingness to separate solid waste in your households.					
2. You feel involved to solving solid waste problems and ready to make efforts to solve the problem.					
3. You want to attend training on solid waste management whenever you can.					
4. The government should provide training on solid waste management in the village.					
5. You think that the solid waste problem is your responsivity.					

Part4 the question about behavior on solid waste management (Level1: least practiced, Level2: practiced at low, Level3: moderate, Level4: high performed, Level5: most observed)

Assessment list	Rating Level				
	1	2	3	4	5
1. Separation of solid waste before disposal.					
2. Separation and collection of organic waste for animal feeding and composting.					
3. Reuse plastic bags.					
4. Disposal of golden apple snail shells in the village's landfill.					
5. Open burning of agriculture residues.					
6. Reuse cans.					
7. Collection of glass bottles and plastic bottles for sale.					
8. Washing of plastic bags and foam before throwing into the bin.					

Recommendations on solid waste

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CURRICULUM VITAE

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