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Waste Composition Evaluation for Solid Waste Management Guideline in Highland Rural Tourist Area in Thailand

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Abstract

This study investigated municipal solid waste generation rate and its composition including the level of knowledge, attitude and practice on municipal solid waste (MSW) management of highland rural tourist area in Chiang Rai Province, Mae Salong Nok Sub-district, Thailand in order to propose the guidelines for effective MSW in rural tourist areas. Samples of MSW were collected during weekdays and several weekends, and separated into 4 categories: general, recyclable, organic and hazardous waste. About 40 % of the MSW consisted of organic waste; plastic bags were widely present, comprising more than 60 % of the mass of the general waste group. Level of knowledge, attitude and practice (KAP) on MSW was evaluated using questionnaires. While respondents scored 80 % and 76 %, respectively, on their level of knowledge of, and attitude to MSW, practice fell far short at only 37 %. The results led to a recommendation to strengthen waste separation at source, implement waste reduction and recycling concepts to reduce the volume of plastic bags, and introduce composting of food waste. The study also highlights economic and financial benefits of waste recycling. Additional value-added could be derived from the organic waste recycling program by promoting production of bioextracts and compost at household level, in order to reduce the amount of organic wastes and carbon emissions. The general and recyclable wastes could also be converted to energy as refuse-derived fuel 2 (RDF-2); the estimated average heating value of this RDF-2 was 23.56 MJ kg^{-1}. To sustain MSW management in tourist areas, environmental education and environmental awareness campaigns are needed, using the appropriate local languages for communication, and introduction of a fairer system based on the polluter-pays principle for the business sector.

Keywords: Municipal solid waste; Practice; Waste composition; Highland; Tourism, Northern Thailand

Introduction

Municipal solid wastes (MSW) are defined as undesirable materials or wastes mostly generated from households and municipal activities [1]. In common with other developing countries in Southeast Asia, Thailand faces an ever-increasing challenge in solid waste management and disposal [2]. Thailand typically generates approximately 0.3-1.44 kg MSW capita^{-1} d^{-1} [3] but has a disposal capacity of only 1.14 MSW capita^{-1} d^{-1} [4]. Up to 22% of the total volume of collected wastes are improperly disposed e.g. by open burning and open dumping [4]. Growing populations, urbanization and changing lifestyles have greatly accelerated the rate of MSW generation [5]. Thus, MSW management is one of the greatest challenges facing municipal authorities today. To provide effective MSW management, it is crucial to be able to access accurate waste composition data [6]. The composition of MSW varies across countries, and also from state-to-state [7]. However, such data are frequently missing in developing countries and especially in rural municipalities [6].

Chiang Rai is the second largest city in northern region of Thailand. Covering both highland and lowland zones, the Regional Environment Office 1 reported that MSW generated from this province was 430,828.2 tons a^{-1}, with only 24.4 % properly disposed of. Only 20.8 % of wastes are re-utilized and 43.2 % of wastes are inappropriately managed [8]. Considering the characteristic of the topology (high-slope areas), narrow roads and limited disposal sites, highland areas of the province face still more difficulty in waste separation, transportation and disposal.

Our study selected Mae Salong Nok Sub-district as a highland model community. Located in Mae Fah Luang District, Chiang Rai Province, this sub-district is mountainous with elevations approximately 1,200 m above sea level [9]. The selected area is one of Chiang Rai's most visited tourist attractions because of its cool temperatures at the highest elevations. Previous studies have reported the high volumes of MSW in the area, result from intensive tourism during the high season [10-11]. Another study of the effectiveness of solid waste management system of the Sub-district Administrative Organization (SAO) of Mae Fah Luang district reported moderate levels of understanding of waste reduction and separation practices among residents, but in practice, the solid waste management policy and plan were ineffective; this study stressed the importance of promoting waste separation among residents [12]. Research on variations in waste characterization among several regions may be valuable in developing appropriate MSW management plans. However, there is a lack of waste composition data for the current study area.

To ensure effective long-term implementation of MSW management plans, understanding public concerns, knowledge and behavior is crucial [13]. Previous studies have evaluated factors associated with these behaviors including knowledge, attitudes, and practices (KAP) at household and community level [14]. The objectives of this paper are therefore to provide an accurate determination of the quantities and composition of MSW generation in the target community and to assess residents' knowledge, attitude and practice in relation to MSW management.

Materials and methods

1) Study area

The study area, Mae Salong Nok Sub-district located in Chiang Rai Province, Northern Thailand. The area is the major border crossing between Thailand and Myanmar as shown in Figure 1. Mae Salong Nok Sub-district has emerged as the province's most popular tourism destinations due to its traditions and cool, picturesque mountainous terrain. To serve the

influx of tourists, many commercial amenities such as hotels, restaurants, stores, and markets have sprung up in the area. The study focused its attention on one specific village in Mae Salong Nok Sub-district: Village 1 (named Ban Santikhiri) is the sub-district's most popular tourist destination and thus subject to the greatest challenges for MSW management.

2) Sampling and data collection

Primary data were divided into 2 categories: (i) determination of MSW quantities and composition; and (ii) assessment of factors associated with residents' behaviors (KAP).

To determine quantities and composition of MSW, samples of household waste were collected from homes, hotels, restaurants and markets by Mae Salong Nok SAO. The sampling of waste generation and composition was performed during weekdays for a month and one time per week during the high tourist season in February, 2017. At the community's landfill site, the waste was weighed using a scale with sensitivity of 0.01 kg, and recorded on a sampling sheet. The bags were separated by weight; small (< 10 kg), medium (10-20 kg) and large (> 20 kg). These waste sample bags were randomly sampled to collect a combined sample weight of 100 kg. The 100 kg of waste was then characterized using the quartering method. The samples were first placed on a polyethylene sheet laid on the floor and thoroughly mixed using a mechanical shovel. Then, the samples were placed in a uniform pile and divided into four quarters following straight lines laid perpendicular to each other. Either pair of opposite corners was then detached to leave half the original sample. This process was repeated until the desired sample size was reached. The surplus 'two-quarters' from the last size reduction was retained for analysis of waste composition, moisture content and bulk density [14].

Following the guidelines of Thailand's Pollution Control Department, for waste composition analysis, the waste samples were separated into four categories: general waste, recyclable waste, organic waste and hazardous waste, as shown in Table 1. Then, the materials were manually sorted into 11 components; organic, plastic bags, packaging, paper, glass, recycled plastics, milk cartons, aluminum cans, papers, metals and others. Each component was weighed and recorded, and the total weight of all components checked compared to the original weight of the samples.

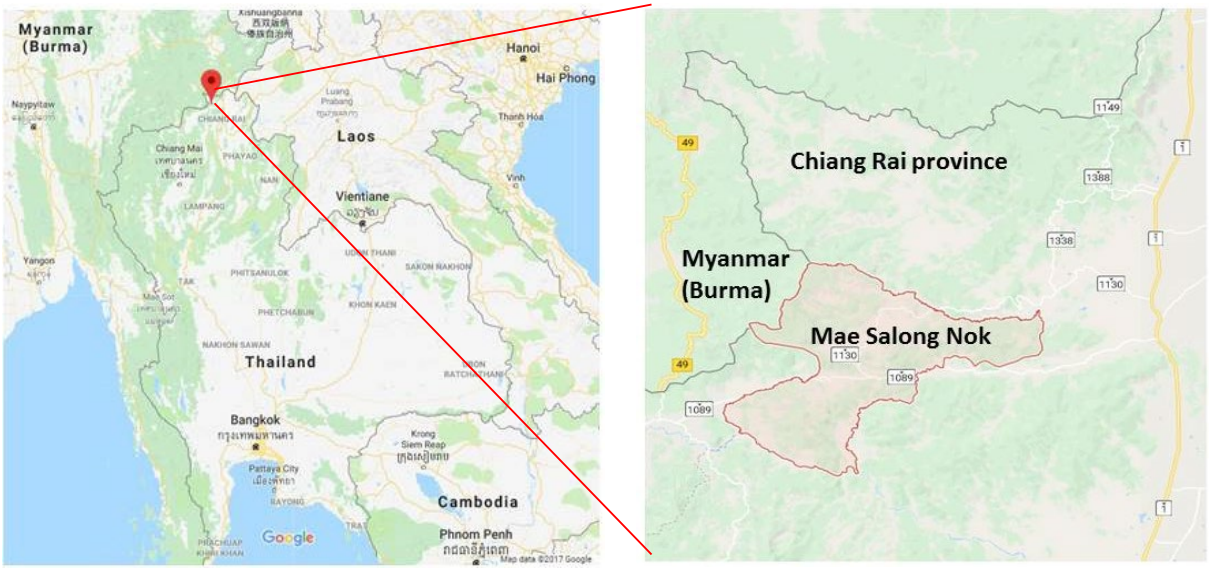

Figure 1 Google map of the Mae Salong Nok Sub-district.

Table 1 Sorting categories of waste regarding to Environmental Protection Agency [14]

Waste categories	Materials included
General waste	Plastic bags, non-recyclable plastics, foam boxes, non-recyclable paper
Organic waste	Food waste, garden waste, leaves, grass, branches
Recyclable waste	Glass, paper, recyclable plastics, milk cartons, aluminum cans, metals, tires
Hazardous waste	Pesticide containers, batteries, pieces of electronic, fluorescent tubes

For assessment of factors influencing residents' KAP, this study conducted a cross-sectional survey from November 2016 to January 2017. The study population resided in Mae Salong Nok Sub-district, Mae Fah Luang District, Chiang Rai Province, Thailand. The sample for this study was calculated by the Yamane formula [16]. The calculated sample size of 214; the size was increased by 10% to 236 to account for error and invalid responses. Respondents were nominated by simple random sampling and interviewed using a standard questionnaire, comprised of four parts. The first part inquired about general demographic information such as age, gender and occupation. The second part comprised 15 questions relating to the respondent's knowledge of MSW management; the questions were organized and close-ended with only a yes/no choice of responses. The third part comprised 10 questions relating to attitude towards MSW. These questions were organized and close-ended, with responses set as a Likert scale. The fourth part comprised 15 questions aimed at understanding MSW management practices of the respondents. Responses were scored on a four-point Likert scale, with responses ranging from "1" (never) to "4" (always). The mean score was computed and interpreted as follows; 1.00-2.00 = poor, 2.01-3.00 = moderate and 3.01-4.00 = good. Descriptive statistics were calculated using SPSS version 20, 2014 (SPSS, Chicago, IL).

3) Recycling and recovery program implementation

In implementing the recycling program, a selected homestay was selected for preliminary evaluation over a 1-week period. Organic waste was separated into two groups: (1) fruit and vegetable wastes for producing bioextract; and (2) food waste for composting. The household voluntarily implemented this recycling program. The amount of organic waste generated by the household was examined before and after the implementation period. The reduced amount of organic waste was converted to estimate CO_2-eq emission savings using the Food Waste Greenhouse Gas Calculator of Watch My Waste website [17].

The recovery program aimed to assess the feasibility of converting general and recyclable wastes to energy as refuse-derived fuel 2 (RDF-2; coarse RDF). General and recyclable wastes could be changed to RDF-2 such as plastic and paper. The heating value of plastic and paper of this study was calculated, following the method recommended in a previous study [18].

Results and discussion

1) Solid waste generation and composition

The main sources of solid waste generation - domestic and tourism activities - contribute about 5.1 tons d^{-1}, or 0.9 kg $capita^{-1}$ d^{-1}. From Figure 2, the organic waste represented the largest component, accounting for 42.79 % of the total weight. The other categories of waste (general waste and recyclable waste) accounted for 29.19 % and 26.53 %, respectively. Surprisingly, medical waste was found mixed with MSW, representing 1.49 % of the total; this was found mostly in general hospital waste. However, a government officer confirmed that this collection was in error. Aside from this, a small amount of

household hazardous waste, such as aerosol cans, was also found. These findings point to the absence of provisions for proper segregation and collection of infectious or otherwise hazardous waste.

Considering waste composition (Figure 2), organic waste included food waste and garden waste; however, it was difficult to measure the exactly amount due to mixing and decomposition. For recyclable waste, the highest percentage by weight of recyclable waste generated were glass (beverage containers), plastics (PET bottles), milk cartons, aluminium cans, paper and metals according to the percentage by weight of 42.50 %, 23.75 %, 22.50 %, 5.00 %, 5.00 % and 1.25 %, respectively. Plastic bags were the largest component of the general waste, representing 63.2 % by weight of total general waste. This was followed packaging (by 20.3 %) and pieces of paper (9.03 % by weight). The result of the waste composition confirmed previous findings relating to the predominance of plastic bags and food waste in the waste stream in tourism areas [19]. For waste generation, the waste generation in study area was slightly below the national average waste generation rate, reported as 1.14 kg capita^{-1} d^{-1} [4]. However, a previous study indicated that the waste generation rate of the tourism area was 1.7 kg night^{-1} guest^{-1} [20]. This study found that some wastes were not collected because some of the study areas were high-slope areas and roads were narrow and often inaccessible, making it difficult to collect waste. Furthermore, the composition of general waste included very large amounts of plastic bags compared with MSW in New York and Cyprus, which were both below 10 % and 2.26 % [21-22]. Similarly, 5.33 % and less than 10 % of glass were found in the recyclable waste stream in New York and Cyprus [21-22]. The organic waste in this study (42.79 %) was lower than those of food waste detectable (61-96.6 %) in Ho Chi Minh City, Vietnam [1].

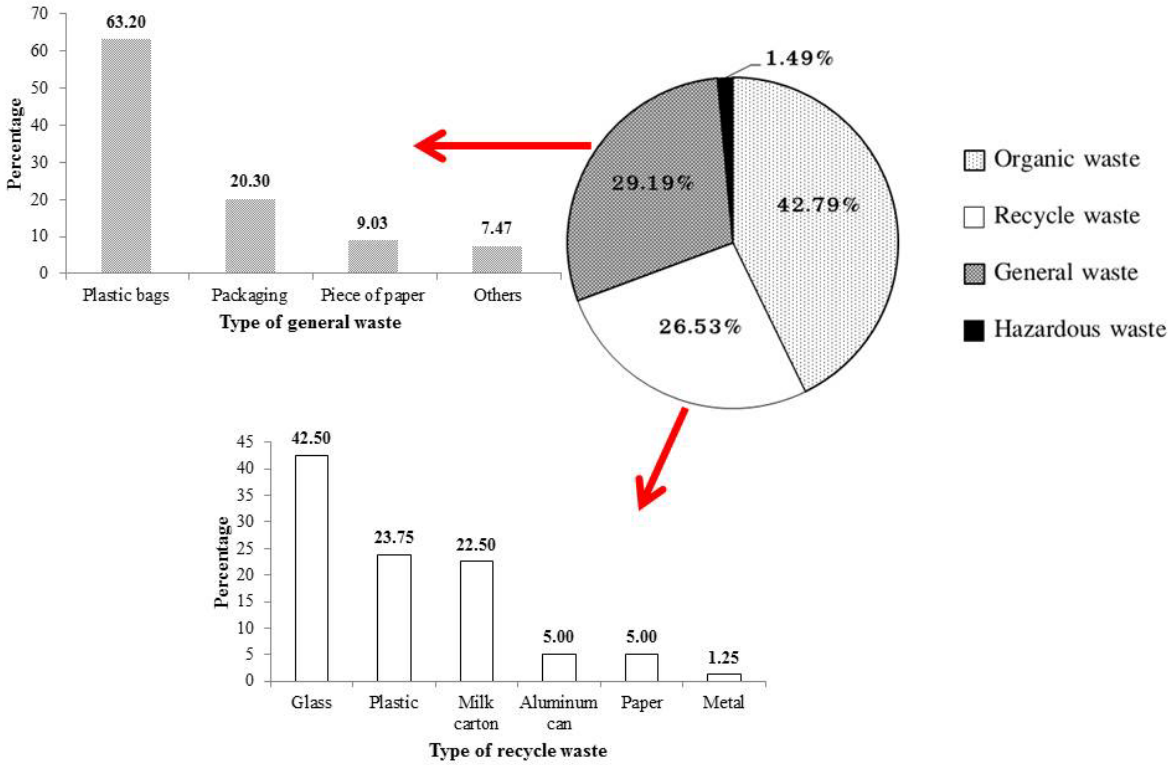

Figure 2 Waste composition of Mae Salong Nok Sub-district.

The results indicate that the composition of waste from accommodation establishments in the tourist area is similar to regular household waste, depending on the services provided. Hotels and restaurants have a higher fraction of organic waste, plastic bags and glass, as has been found in tourist areas elsewhere, e.g. in Europe [23]. Moreover, it was also observed that many hotels, restaurants and even households with poor sorting, residual waste is the dominant fraction. Therefore, efficient waste separation at source is needed in order to implement effective MSW management in the current study area.

2) MSW management practice

Of the 236 survey respondents, 62.3 % were female, with 35.6 % between 20-40 years old, and 22.5 % from 41-60 years old. 23.3 % were under 20 years of age. In terms of occupation, 35.2 % of respondents were merchants, followed by other occupations such as students and tourists (18.2 %) and freelance (11.4 %).

The level of KAP of respondents on MSW management was scored using respondent responses. The scores indicated a high level of knowledge (80 %) and attitude (76 %) of MSW management among respondents. However, the level of practice on MSW management was strikingly low at 37 %, as shown in Figure 3 (a). Similarly, a research indicated that awareness had affected their waste management practices specifically on segregation, reduce, reuse, and recycle [25]. However, it is possible that respondents may have over-stated their attitudes to please interviewers. Apart from awareness, the relations among beliefs, attitudes, behavioral intentions and behaviors in various fields such as advertising, public relations, advertising campaigns and healthcare also play an important role [26]. A previous study indicated that Thailand still lacks appropriate environmental education and environmental awareness campaigns at national as well as local levels [27]. Furthermore, this study found that some of MSW management campaigns were unsuccessful because of inadequate consideration of language. This study area has a rich variety of hilltribe ethnic groups and a diversity of languages aside from Thai. This is therefore a serious communication barrier to adoption of good MSW management practice.

Considering that the study area is a famous tourist place in Chiang Rai Province, the impact of tourism activities needs to be considered and factored into MSW management plans. A previous study in Minorca, Spain, found that a 1 % increase in the tourist population resulted in an average increase in MSW generation of 0.282 % [28]. Therefore, group of tourist and occupations related to tourism such as merchant and business owner (accommodation) had been studied and its impact on MSW management practice. The study found that tourist groups, merchants and business owners had a low level of practice of MSW management compared to residents, as shown in Figure 3 (b). These findings confirmed results of similar work indicating that the highest amount of waste generation among occupational groups was related to private sector services [29]. Residents (such as housewives or farmers in this study) separated and collected 47.3 % more recyclable waste per capita than the average tourist [28]. Government employees are the lowest level of adoption. The difference in the level of MSW management practice among the different occupational groups was probably related to their awareness of environmental pollution issues and impact [30].

Considering Table 2, the questions for MSW management included both good and poor practices. The MSW management practice of respondents had been in the good level such as “Put garbage in the bin”, “Separate recyclable waste” and “Take plastic or glass bottles for utilization and selling”. However, 50.8 % of respondents reported regular separation of

waste for recycling. This finding was below that found in a previous study in Bangkok, in which 66 % of Bangkok residents reported separation of household waste for recycling [27]. The MSW management practice of respondents in this study was ranked as moderate to poor for questions such as "Refuse plastic bag" and "Use baskets or fabric bag for shopping". This result was consistent with the composition of waste as determined, with plastic bags accounting for more than 60 % of the total waste stream. This finding provides a useful guide to defining priorities for a MSW management plan to reduce the overall amount of waste. However, this will be ineffective without a significant increase in practices by household residents and businesses. Thus, an appropriate area-based waste management should be considered, since the results of studies done in other locations with different characteristics cannot contribute meaningfully to making the right decisions for achieving effective and sustainable MSW management in the study area [29]. For successful implementation, some municipalities have introduced MSW management based on unit-based pricing under the legal framework [20].

3) Waste composition and waste hierarchy

Sustainable waste management systems should be urgently introduced at all popular tourist destinations where unsustainable tourism pressure may lead to significant local environmental impacts and ultimately degrade the quality of the attraction from a tourist perspective [31]. Concepts such as "waste hierarchy" or "zero waste" developed under the 3Rs policy propose to change current prevailing principles for MSW management. However, in the context of Thailand, existing laws and regulatory frameworks have not incorporated, embedded or incentivized these concepts. The laws merely provide a mandate to local government to collect and dispose all types of wastes.

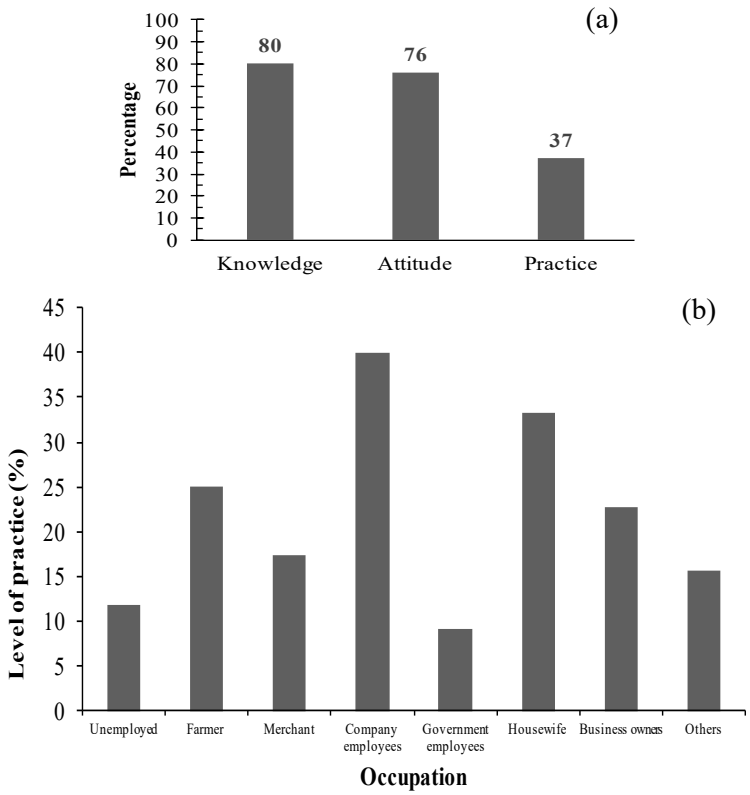

Figure 3 Graphs showing (a) percentage of KAP level and (b) practice level of each occupation.

Table 2 Frequency of MSW management practice

MSW management practice	Frequency of MSW management practice (in %)				Average
	Always	Frequently	Sometimes	Never	
1. Put garbage in the bin	75.0	10.6	13.1	0.8	3.59
2. Burn waste in your home area	1.3	4.7	19.5	74.2	1.32
3. Seperate food waste to feed animals or compost	36.4	19.5	22.5	20.8	2.70
4. Seperate recyclable waste	50.8	18.2	16.1	14.4	3.05
5. Seperate hazardous waste	38.6	14.8	16.9	28.8	2.61
6. Refuse plastic bags	11.0	14.4	32.6	42.4	1.95
7. Use baskets or fabric bags for shopping at supermarket or market	13.1	19.1	33.9	33.1	2.11
8. Purchase the product with less packaging	13.6	16.5	48.3	19.9	2.20
9. Tell the member of your household to use the least waste product	25.8	24.2	26.3	22.9	2.51
10. Reuse the plastic bags	39.8	31.4	17.4	11.0	2.99
11. Use materials or containers that can be reused.	31.8	32.2	22.9	12.7	2.82
12. Take plastic or glass bottles for re-utilization or selling	51.7	28.0	10.2	9.7	3.21
13. Take paper boxes or old newspapers for re-utilization or selling	42.8	28.8	18.2	9.3	3.03
14. Contribute to providing information and suggest the solution on MSW problem in your community	27.1	19.1	26.7	26.7	2.46
15. Encourage neighbors to aware and solve the MSW problem	25.0	23.7	25.0	25.8	2.47

Organic waste is dominant in the waste stream of Mae Salong Nok Sub-district, with recyclable waste and plastic bags mixed in; this non-degradable component leads to major health and environmental impacts [32]. To make the waste hierarchy easier to use by hotels, restaurants, markets, shops and catering businesses, a locally-adapted waste hierarchy has been developed for this study area (Figure 4), adapted from the standard food and drink material hierarchy [33]. In terms of preventive steps, local municipality should promote procurement of raw materials and ingredients and supplies with minimum packaging. Organic waste should be used to feed livestock. For recycling steps, some organic wastes should be utilized to produce biogas or make compost to use in household or business sectors such as hotels and restaurants. The recyclable waste should be separated at source and sold to itinerant recyclable buyers. In the least preferable option (disposal), general waste should be disposed in sanitary landfill or incinerated without energy recovery. The medical waste should be collected and sent to Sub-district Health Promoting Hospital to be properly disposed and household hazardous waste should be collected and sent to SAO for specialist disposal.

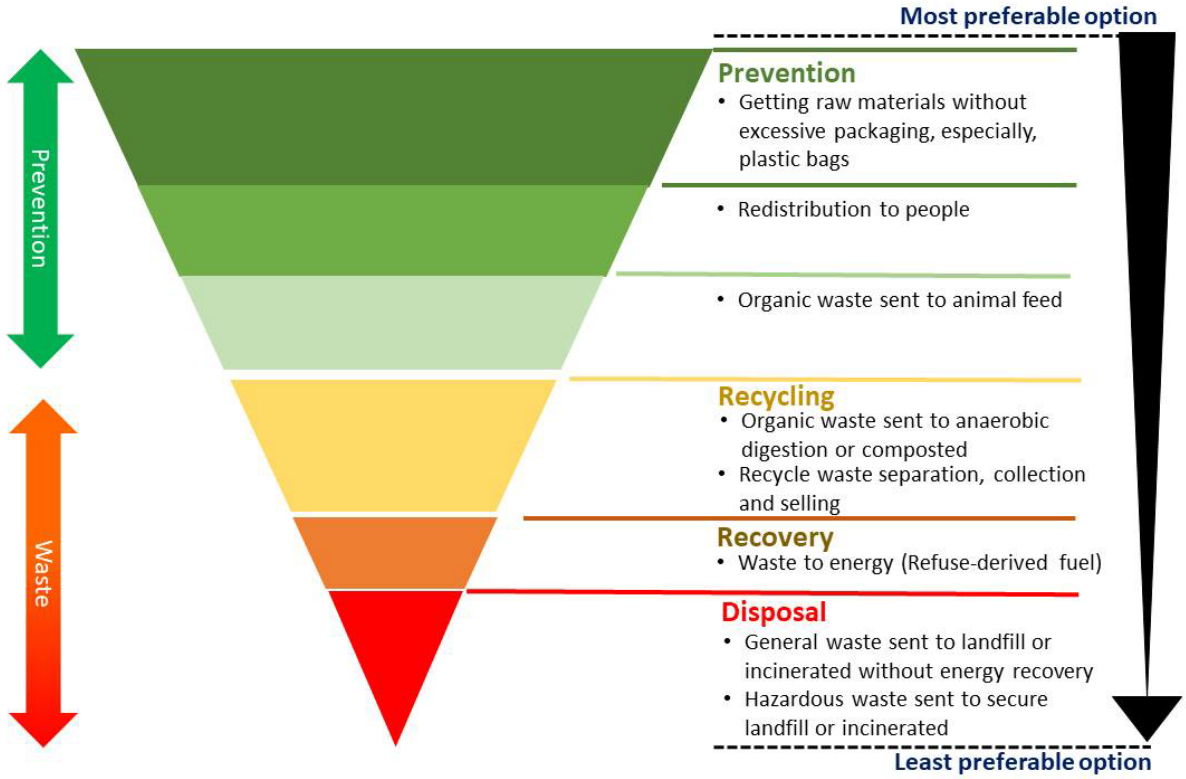

Figure 4 Waste hierarchy for this study area (adapted from WRAP [33]).

In the context of a rural tourism area such as Mae Salong Nok Sub-district, separation of food and organic waste for feeding to livestock and/or composting is recommended to reduce the overall volume of waste and mitigate transport costs and environmental impacts. A plastic bag reduction program should be introduced, based on an awareness campaign targeting households and businesses. Although legislation e.g. a ban on plastic bags in forest areas and plastic bag charging may prove most effective as interventions, local people need to have a clear understanding of the need for such measures. Legislation may also be impractical for the study area because of its remoteness, language barriers and the lifestyles of villagers. Therefore, promotion and development of indigenous knowledge to create and use products in the study area shops, such as using traditional baskets, bags and containers made by the hill-tribes themselves. This promotes the hill-tribes' products and generates income for people in the area. Shop owners also should cooperate with buyers to promote the "refuse plastic bags" campaign and promote use of cloth bags. Shop owners would thereby save on the cost of purchasing plastic bags. Community leaders will play a major role in influencing and motivate their communities.

Although the material hierarchy in Figure 4 does not clearly present recyclable waste management, previous studies have reported a range of benefits from implementing zero waste management, as follows: (i) benefits to the community; (ii) economic and financial benefits; (iii) environmental benefits; and (iv) specific benefits for industries and their stakeholders [34]. From the study, the economic and financial benefits of effective recycling, waste separation and collection, can be estimated for the study area. Sales of recyclable waste (glass, aluminium cans, metals, paper, wood, plastics and tires) for the study area should be estimated and used to motivate and drive

changes in waste separation behavior among villagers. The Mae Salong Nok SAO also collected some types of recyclable waste such as plastic bottles and aluminum cans and sold to itinerant recyclable buyers from lowland areas who did not buy and pick up frequently. However, the SAO of Therd Thai Sub-district, close to Mae Salong Nok Sub-district, also collected recyclable waste for sale in lowland areas of the province. This would thus also be a good model for Mae Salong Nok SAO to follow. For hotels, motels and restaurants, initial promotional efforts by the local government efforts should focus on providing knowledge and skills for waste separation, organic waste management such as livestock feeding and making compost, vericulture and bioextracts to use in gardens. Moreover, the Department of Environmental Quality Promotion (DEQP) and local government should promote green hotels, motels and restaurants through campaigns to reward compliance by hotels, motels, and restaurants over the long term. To create incentives or motivate business sector, it should apply a fairer system that not only reflects seasonal variations but also reward effective waste management at source based on the polluter-pays principle [20]. Local municipalities should collect waste management fees from businesses at a higher rate than that for residents because these sectors generate a higher amount of waste. Waste management charge rate should thus be volume-based.

4) Recycling and recovery program implementation

Organic waste was found to account for approximately 42.79 % of total waste volume. In the proposed waste hierarchy for this study area, organic waste has been divided into two groups: (1) fruit and vegetable wastes for producing bioextracts; and (2) food waste for producing compost. Consequently, it is recommended that organic waste be segregated and processed at the household level. The preliminary evaluation of this implementation program was conducted at a selected homestay over a 1-week period. The amount of organic waste before and after the program implementation was measured (Figure 5). Following implementation, a dramatic reduction in measured amounts of organic waste was found, from 12.60 to only 0.22 kg $week^{-1}$ $house^{-1}$ (98.25 %). In terms of environmental impact, the 12.38 kg of organic waste could be reduced CO_2-eq emission by 23.52 kg $week^{-1}$ $house^{-1}$ [17]. This indicates that the implementation program at household level was highly effective and should be promoted more widely, since it is able to reduce both organic wastes and CO_2-eq emissions.

Figure 5 Organic waste in a representative household to make compost and bioextract in (a) before and (b) after of implementation program at household level.

The waste recovery component of this study examined the feasibility of converting general and recyclable wastes to energy in the form of refuse-derived fuel 2 (RDF-2; coarse RDF). Two categories of general and recyclable wastes can be converted to RDF-2 (Table 3); these are (1) plastics 30.6 % (plastic bags 18.4 %, packaging 5.0 % and containers, 6.3 % by weight) and (2) paper 9.8 % (pieces of paper 2.6 %, milk cartons 5.9 % and paper 1.3 %). A previous study showed that the heating values of plastic and paper were 25.00 and 19.00 MJ kg^{-1}, respectively [18]. This study evaluated the heating value using the ratio of plastic to paper of 3.1:1.0. The average heating value of RDF was thus estimated at 23.56 MJ kg^{-1}, compared with 25.12 MJ kg^{-1} for coal [18].

Conclusion

In this study, solid waste generation and its composition were measured in order to assess the status of solid waste characteristics in Mae Salong Nok Sub-district, Chiang Rai Province. The waste composition data were used as a basis for recommendations and guidelines for improvement in waste management in rural highland tourist areas such as Mae Salong Nok Sub-district. The study found that the 3Rs (Reduce, Reuse and Recycle) concept offered a good overall guideline for local implementation, particularly considering the high contribution of plastic bags (63.20 %) within the waste stream- this is much higher than typically observed in other countries. Organic waste represented 42.79 % of the daily waste stream, offering an opportunity to utilize this component for production of compost. The local government can play a major role in promoting waste separation and in collecting recyclable waste for sale buyers in lowland areas. Initial promotional efforts by local government agencies should focus on providing knowledge and skills for waste separation and organic waste management among business owners and operators. Local government agencies, together with DEQP should initiate campaigns to stimulate green hotels, motels and restaurants, and introduce incentive schemes to drive long-term behavioral change. Importantly, effective waste separation and collection should be urgently prioritized in the study area. In addition, environmental education and awareness campaigns should be delivered in local hilltribe languages as well as in Thai. WSM management system should apply a fairer system that not only reflects seasonal variations but also incentivizes waste management at source based on the polluter-pays principle. The waste management charge rate should be volume-based. Moreover, to provide the appropriate area-based MSW management for Mae Salong Nok Sub-district, it is recommended in the future to assess the effects of tourism volume, tourism quality and tourism specialization on MSW generation.

The organic waste recycling program implemented at a local homestay was successful in producing bioextracts and compost, and resulted in greatly reduced volume of organic wastes and associated CO_2-eq emissions. Finally, the waste recovery indicates that the characteristics of locally generated general and recyclable wastes makes them suitable for conversion to energy as refuse-derived fuel 2. Using a ratio of plastic to paper of 3.1:1.0., the average heating value of RDF derived from these sources was 23.56 MJ kg^{-1}.

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Table 3 Average heating value for RDF in different types of waste

Type of waste	Plastic			Paper		
	Bags	Packaging	Containers	Pieces of paper	Milk cartons	Paper
Percentage of waste composition (% by weight)	18.4	5.0	6.3	2.6	5.9	1.3
Total percentage of waste composition (% by weight)		30.6			9.8	
Ratio of plastic to paper		3.1			1.0	
Combustible fraction in waste composition		0.76			0.24	
Heating value (MJ kg^{-1})		25.00			19.00	
Average heating value for RDF(MJ kg^{-1})			23.56			

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