

Comparative Analysis of Solid Waste Management in Thailand and Japan: Solid Waste Management System and the Best Practice

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Abstract

This study aimed to compare the factors causing affective and ineffective Solid Waste Management (SWM) in Uonuma city in Japan and Mae Chan District in Thailand, and to determine the best way to apply Japanese solid waste management techniques in Mae Chan District, which could serve as a waste management guideline for agricultural areas in Thailand in the future. The findings showed that waste generation and composition in Mae Chan District and Uonuma city were not considerably different; however, waste sorting in Uonuma city, like in every city in Japan, is well-organized, prioritizing the separation of waste into combustible and noncombustible categories for proper disposal through incineration. From the comparison, the main factors indicating the ineffective SWM in Mae Chan District included inadequate waste sorting system, waste collection and transportation, leading to opening dumping, uncooperative waste treatment and disposal resulting in a negligently operated landfills, lack of strict policies and regulations allowing open burning, and inconsistent proper waste sorting practices, waste collection and transportation. Therefore, it is advisable to formulate improved policies and regulations that advocate for the 3Rs, mandate solid waste management (SWM) service fees and violation penalty fees and provide information about SWM to enhance the waste management situation in Mae Chan District.

Keywords: Solid waste management; Agricultural waste; Japan; Thailand; Comparative study

1. Introduction

Solid waste problem is an environmental issue that directly affects not only human health but also community, economy, and environment in urban areas of developed and developing countries as stated by United Nation (UNEP, 2009). Solid waste management (SWM) is an important environmental health service and an integral part of urban environmental planning. The Urban Development Sector Unit in the East Asia and Pacific Region reported that the urban areas in Asia generated about 2.7 million m³ of municipal solid waste (MSW) per day in 1999. This figure is expected to increase to 5.2 million m³ per day by 2025.

In Thailand, 17,475 tons of MSW were generated every day in 2011, increasing from 2010 for 5.14%. The highest waste generation rates were observed in urban municipalities and subdistrict municipalities, accounting for 40% and 38% of the total, respectively. In terms of regions, the northeast region and Bangkok showed the higher waste generation rates at 26% and 21% of the total, followed by the central, northern, southern, eastern, and western regions at 16%, 15%, 12%, 6%, and 4%, respectively. According to the Thailand State of Pollution Report 2020, the total amount of solid waste generated in Thailand was approximately 27.35 million tons. Although it decreased by 4% from

2019, only 11.19 tons of waste were disposed appropriately, while around 4.23 tons of waste was improperly disposed (PCD, 2020)

The assessment of the current situation of urban solid waste management system is important for any city, primarily due to environmental concerns. Many research studies have proved that most environmental problems, e.g., greenhouse gas emissions, water pollution, soil pollution and resources depletion, were linked to poor waste management systems. Thus, starting at municipal level, waste management must be effective for sustainable development. However, several health concerns in Thailand involves ineffective solid waste management. A significant number of municipalities have been particularly dealing with ineffective storage tanks, unsafe waste collection, and uncontrolled waste disposal such as open dumping and burning. Open agricultural burning, identified as a potential source of haze, emits pollutants directly into the atmosphere of Thailand, especially in the northern region (PCD, 2012). The conduct of open agricultural burning and biomass is commonly for waste disposal, accelerating crop rotation, and controlling pests and diseases in most parts of northern Thailand. The current surge in contract farming, with some large organizations promoting monocropping of corn and other cash crops, has led to the accumulation of waste after the harvest season (Adeleke *et al.*, 2017). The large amounts of waste are disposed by open burning because of several reasons including low labor intensity and cost. However, open burning significantly releases high volume of pollutants into the atmosphere, causing air pollution, which has become a major public health challenge, especially in northern Thailand.

The key to overcome the municipal solid waste problems lies in increasing reuse, recycling, and recovery rates. These principles of reuse, recycling and recovery are becoming more widespread, particularly in densely populated countries such as Japan, where a remarkable adoption of the principles has been observed. In the 1990s and 2000s, various recycling laws were enacted in Japan, incorporating fundamental measures to control

waste management, including pollution prevention, reuse, recycling, and waste incineration with air pollution control (Okuda & Thomson, 2007). Japan's efforts produced outcomes, as the amount of municipal solid waste generated in 1992 decreased to 50.20 million tons compared to 50.77 million tons in 1991. The decrease can be attributed to the promotion of the appropriate strategies for waste reduction (Sakai, 1996). Pay As You Throw (PAYT) is a principle that has been adopted by developed countries as an important tool for solid waste management since the 1990s. PAYT is considered an effective step-by-step guiding policy for promoting the 3Rs-reduce, reuse, and recycle. Changes in the mindsets of Japanese residents in response to PAYT have had a huge impact on waste control regarding reduction and reuse which are fundamental aspects of waste management (Sakai *et al.*, 2008).

Apart from waste recycling and separation being instrumental in the reduction of solid wastes in Japan, biomass utilization technologies have also contributed to the effective management of agricultural waste in Japan. This has been achieved by establishing a recycling society and addressing food production waste (Ministry of Environment, Japan, 2012). However, such principles and technologies are yet to be successfully applied in Thailand. Several reasons are associated with the less effective solid waste management in Thailand, including limited budget, low awareness levels, the types of available technology, and the attitudes and expertise of stakeholders. In addition, the dearth and weakness of autonomous civil society organizations, the dominance of traditional top-down and non-participatory styles of public administration among municipal authorities, and deep-rooted patron-client relationship between the local government officials and community members undeniably undermine the development of heightened environmental awareness, public education, and a sense of co-production and partnership needed for the waste separation project (Charuvichaipong & Sajor, 2006).

Thailand needs to assure appropriate management and deploy available technologies to improve the country's waste situation.

As a developing country, Thailand could learn from experienced and developed countries like Japan. When comparing the solid waste management and technologies between environmentally well-managed Japan and less well-managed Thailand, it is important to consider the context of both developed and developing economies. Applying the exact waste management system used in Japan to less prosperous countries could be challenging. For instance, the technology of incineration is relatively expensive and may not be suitable for weaker economies. However, legislative measures, as well as the 3Rs principles (reduce, reuse, and recycle) widely practiced in Japan, can be incorporated into the waste management system of developing economies to tackle the problems of ineffective waste management (Mahajan, 2015).

In recent years, Chiang Rai has become one of the most visited provinces in Thailand. Tourism has grown, and urbanization has expanded, with the number of tourists in 2018, before the outbreak of COVID-19, reaching 3.68 million, an increase of 26.35% from 2013 (Tourism and Sports Ministry, 2018), hence resulting in the high rate of municipal waste generation. The rapid growth contrasts with ineffective municipal solid waste management (MSWM), where unsafe waste collection and uncontrolled waste disposal, such as open dumping and burning, still have been found in many municipalities (Techateerawat, 2009).

Waste in the Chiang Rai Province is not only generated from urbanization and tourism, but a significant amount of agricultural waste is also produced in Mae Chan District, known for its rice and corn farming in the province. With around 76,554 rai (approximately 12,248 hectare) of rice fields, the district is home to 18,069 farmers and approximately 44 households involved in corn cultivation (Chiang Mai Office of Agricultural Extension and Development 6, n.d.). The district is committed to promoting high-quality agriculture, particularly in growing rice similar to the renowned Uonuma City in Japan. However, agricultural waste management in the Mae Chan district, as well as in Chiang Rai Province itself, still relies on open burning practices

(Adeleke *et al.*, 2017); consequently, solid waste management (SWM) considerably lacks effectiveness.

It is essential to examine the SWM problems in the district for potential improvements. The adoption of Japanese SWM techniques or technologies could be particularly beneficial for Thailand. Nevertheless, a preliminary comparison between the SWM of Mae Chan District and a Japanese city is necessary to identify similar and different factors contributing to the success and ineffectiveness of SWM in both countries. Uonuma City in Niigata Prefecture, Japan, is an ideal counterpart for comparison, given its topographical similarity to the expansive rice-farming areas of Mae Chan district. To compare both study areas, it is crucial to gain an understanding of their SWM techniques, technologies, policies, and regulations. The objectives of this research are to examine the factors responsible for effective and ineffective SWM in both Uonuma City and Mae Chan District, and to suggest the appropriate way to apply Japanese SWM techniques in Mae Chan district. This application can serve as a guideline for SWM, especially agricultural waste, in agricultural areas in Thailand for the future.

2. Methodology

The study is a descriptive-comparative research of solid waste management (SWM), focusing on factors responsible for effective and ineffective SWM in Thailand and Japan and the best way to apply Japanese techniques and practices to the SWM system Thailand. The examination and data collection took place between 2016 and 2018, predating the COVID epidemic. The main aim was to reduce the impact of infectious waste, including masks and hospital waste, which were likely to increase and disrupt the established waste management patterns. Another goal is to create a guideline for agricultural SWM in Thailand. Hence, it is important to note that the present situations of SWM in both areas might be slightly different from the time of the study.

2.1 Study area

For the potential exchange of knowledge, practical strategies, and technologies for SWM between Thailand and Japan, the research focused on Mae Chan District in Chiang Rai Province, Thailand and Uonuma City in Niigata Prefecture, Japan. The selected study areas share similar topography, characterized by mountains and flat land with extensive rice fields. Moreover, agriculture is the main occupation for residents in both cities. In Chiang Rai, 52% of the population are farmers (Statistical Office, 2018), while the agricultural area in Niigata increased to 66,914 hectares from 2005 to 2012 (Ministry of Agriculture, Forestry and Fisheries, Japan, 2019). The similarities in occupation and landscape suggest that solid waste composition and management in both areas could be comparable.

In addition to the mentioned similarities, additional criteria for selecting both areas in this study included the presence of their official waste management organizations and their permissions granted to the researcher for conducting research. The study area in Mae Chan District is under the responsibility of Mae Chan Subdistrict Municipality and Mae Chan Subdistrict Administrative Organization. Meanwhile, Minami-Uonuma, situated in the south of Uonuma, is the study area for Uonuma City.

2.2 Data collection and analysis

To compare and identify factors, techniques, and technologies contributing to successful SWM in both areas, data on five aspects, including waste generation composition, waste categories and sorting, waste collection and transportation, waste treatment and disposal, and policy and regulations, were mainly obtained as secondary data. These data were gathered in the form of documents directly from the Mae Chan Sub-district Municipal Office, Uonuma's Japan Agricultural Cooperatives (JA Group), and Eco-plant Uonuma during the researcher's visits. Primary data on the five aspects were also acquired through field observations in both study areas by

the researcher. Photographs related to waste management, such as garbage bins, dumping grounds, and surrounding areas from different parts of both study areas were taken during the field observations to enhance clarity and provide a visual understanding. In Japan, the researcher also attended an Eco-Plant Uonuma tour arranged by the officer and staff in charge.

Secondary data from the official documents and primary data from the field observations were analyzed with content analysis (Krippendorff, 2019). The data from Uonuma and Mae Chan were organized and categorized into the five aspects, including waste generation composition, waste categories and sorting, waste collection and transportation, waste treatment, and waste disposal. After that, the data from both study areas were compared in each category to identify similarities and differences. Finally, conclusions were drawn regarding the presence or absence of factors that made waste management in Mae Chan less successful than in Uonuma.

In terms of reliability and validity, the data in this study were derived from documents obtained directly from reputable and consistent organizations in both countries to ensure the accuracy of the data. Field observations in both study areas were also conducted in the same manner to ensure the credibility of the comparison. Photography and notetaking covered the same data needed in both study areas. It is noteworthy that waste management practices observed during the field observations in both study areas were identical to the information in the official documents.

3. Results and Discussion

This research project uncovered the reasons behind the ineffectiveness of SWM in Chiang Rai Province. It compared key factors contributing to effective SWM in Thailand and Japan, aiming to determine the best way to apply Japanese SWM techniques and potential technologies in Chiang Rai. Additionally, the research aimed to propose a guideline for agricultural SWM in Thailand. The findings showed both significant and minor differences in various waste management

aspects, including (1) waste generation and composition (2) waste categories and sorting (3) waste collection and transportation (4) waste treatment and disposal and (5) policy and regulations.

3.1 Waste generation and composition

The total solid waste generated in Mae Chan District was 6.665 tons per day with a waste generation rate of 1.78 kilogram per capita per day. In terms of solid waste composition in Mae Chan district, general waste was the most prevalent at 33%, primarily due to the high volume of consumer goods and food packaging, such as plastic bags, snack wrappers, and plastic straws. These items are considered kitchen waste in Japan and are typically treated in incineration. Recyclable waste, including paper, plastic bottles, glass, and metal, accounted for 31%, followed by biodegradable waste at 26%, primarily consisting of food waste from residential areas. Hazardous waste constituted only 1%. In Uonuma City, more than 64.6% of the waste composition was paper. The waste generated from kitchens accounted for around 16.9%. Moreover, waste in group 1 (vinyl, rubber, leather), group 2 (wood, bamboo, straw), incombustible waste, and other wastes were found at 12%, 5.6%, 0.2% and 0.9%, respectively. The overall types of waste found in both study areas were remarkably similar, ranging from recyclable waste to food waste. It is worth noting that paper waste in Uonuma was found to be less than general waste in Mae Chan. The reason could be that in Thailand, for extra money, households usually sell recyclable waste such as paper and electronic parts to informal sectors who collect, buy, and send the recyclable waste to recycling factories without the municipal government's cooperation (PCD, 2020). On the other hand, people in Japan do not have to sell the paper waste since the municipal government is responsible for recycling. However, when comparing waste generation and composition between Mae Chan and Uonuma, the findings revealed minimal differences. Consequently, this aspect cannot be identified as the cause of less effective SWM in Chiang Rai.

3.2 Waste categories and sorting

Table 1 shows that the waste generation rate per person per day in Mae Chan (1.8 kg) was more than twice as high as in Uonuma (0.7 kg). The waste generated in Thailand is classified into typical Thai waste types, which include general waste, recyclable waste, compostable waste, and hazardous waste. In contrast, the data for waste generated in Uonuma is presented in specific groups based on waste composition. The waste categories in Uonuma, in fact, include recyclable, combustible, non-combustible, bulky waste, and hazardous waste. In Japan, each city adopts a distinct waste sorting system aligned with its specific waste management objectives. The solid waste categories in Uonuma and Mae Chan are significantly different. Therefore, a careful examination is needed when comparing waste sorting in both areas, especially for general and compostable waste. For instance, plastic food bags and snack wrappers are considered general waste in Thailand, but in Uonuma, they are kitchen waste and categorized as combustible waste. Similarly, while garden waste and food waste are sorted as compostable waste in Mae Chan, they are categorized as combustible waste in Uonuma.

Waste in Japan is categorized as combustible and non-combustible, owing to the widespread use of incineration technology in every city. The fact that the technology is not yet available in Mae Chan results in the absence of the two categories. In Mae Chan, the absence of this technology leads to the lack of these two categories. However, the absence of certain waste categories and treatment technology does not definitively confirm less effective SWM since it is also important to assess the effectiveness of waste sorting. According to Knickmeyer (2020), storing solid waste in correct containers can prevent waste contamination and enhance the effectiveness of waste reuse and recycling. Therefore, the waste containers in Mae Chan and Uonuma were observed. The differences in solid waste categories in the study areas are accordance to the waste containers. Figure 1 illustrates the types of waste containers and sorting in Mae Chan District and Uonuma City.

In Mae Chan, waste containers in four different colors are assigned to store four different types of waste as shown in Figure 1a. While most Thai people have a basic understanding of which color corresponds to each waste type, there is also text indicating the list of waste for each container. However, the faded text on the containers may result in incorrect waste sorting, particularly for individuals who are uncertain about the meanings of colors and waste types (Shekdar, 2009). Therefore, it is necessary for people in Mae Chan to be educated about colors corresponding types of waste to ensure correct waste sorting. Contrarily, the waste containers in Uonuma are all in the same color, but they feature images and names of waste examples, as shown in Figure 1b. The images of glass bottles and metal cans represent non-combustible waste, PET bottles for recyclable waste, paper scraps and disposable chopsticks for combustible waste. Additionally, each waste container usually includes sorting holes to prevent disposal of incorrect types or sizes of waste. For waste placed in bags, the colors of the garbage bags are designated for each waste type. Despite the differences, it can be said that both Uonuma and Mae Chan have the proper waste containers. Thus, external factors like waste categories and waste containers are less likely the major problems causing the less effective SWM in Mae Chan District. It is more important to give attention to other aspects which will be discussed in the next sections.

3.3 Waste collection and transportation

In Mae Chan District, the curbside collection service is operated for collecting

solid waste at the households. The collection points are also located on the roadside or in front of the houses. Some area the district, the alley collection service is also provided to collect solid waste from waste containers located in front of each alley. However, in some remote and less populated areas of the district where the alleys are too narrow for garbage trucks to access, waste is usually discarded to dispose in collection sites chosen by the residents, which has brought a health concern. In Uonuma City, the collection sites are on the roadside with the containers for every type of waste and the area for garbage bags, as shown in Figure 2. This is consistent with the findings by Mahajan (2015) that in Japan, the garbage trucks collect the waste discarded correctly in the containers or bags. There are waste collection dates for each type of waste so people must discard their waste on the correct dates for a pickup. People who want to throw away bulky garbage must bring it to the Eco-Plant Uonuma for disposal. For this aspect, Japan has a more organized collection system than Thailand. The waste collection and transportation system that still cannot thoroughly collect waste and allows unofficial waste collection sites can partly be the causes of the ineffective SWM in Mae Chan District, Chiang Rai Province.

3.4 Waste treatment and disposal

In Mae Chan District, recyclable wastes are mostly sold to the waste collecting and buying markets before being recycled in factories without any municipal involvement. For general waste, they used

Table 1. Waste generation rates and sorting for Mae Chan and Uonuma

Study areas	Waste Generation (kg/cap./day)	Waste Sorting					
		Types and composition (%wet weight basis)					
Thailand	1.8	General waste	Recyclable waste	Compostable waste		Hazardous waste	
		33.0	31.0	26.0		1.0	
Japan	0.7	Paper	Kitchen waste	Vinyl Rubber Leather	Wood bamboo straw	Non-combustible waste	Others
		64.6	16.9	12.0	5.6	0.2	0.9



(a)



(b)

Figure 1. Types of waste container and sorting (a) Mae Chan District (b) Uonuma City

to be collected and transported to Mae Sai Material Recovery Facility for RDF (refuse-derived fuel) production. However, due to the inefficient separation of plastic waste by the public that hindered the RDF production and the cost of transporting RDF to purchasing companies, Mae Sai Material Recovery Facility had to cease operations. As for the landfill operations in Mae Chan District, out of the 6.66 tons of waste generated per day, only 31% is effectively sorted as recyclable waste. Consequently, a large amount of solid waste is still being disposed of in the landfills without proper waste treatment processes, as reported by Sukholthaman & Sharp (2016). The problem lies in the poorly designed and improperly operated landfills, lacking a liner and daily cover; hence, it become an open dumping as illustrated in Figure 3a and revealed by Kaosol (2009). It should be noted that there are two government sections, the municipality,

and the sub-district administrative organization (SAO), that handle SWM in their respective areas but use the same landfills without proper cooperation. This dearth of cooperation could be a reason for the ineffective operation of the landfills in Mae Chan District, leading to open dumping. Furthermore, a large amount of waste in Mae Chan is also disposed of through open burning, especially for agricultural waste, to reduce daily waste volume sent to the landfills. Interestingly, agricultural byproducts, particularly rice straw, are not considered waste in Uonuma City. As depicted in Figure 4, to maintain soil quality, farmers in Uonuma use rice straw as mulch to protect the soil surface from runoff. In contrast, farmers in Mae Chan resort to open burning to eliminate rice straw without considering its usefulness and environmental impact. Therefore, implementing the use of rice straw as mulch in Mae Chan could help reduce agricultural open burning.

In Uonuma City, the municipality is responsible for selling the recyclable waste collected from collection points to recycling factories. Combustible wastes such as paper, plastic bags and wrappers, rubber, leather, and leaves are treated by an incinerator in the Eco-Plant Uonuma to reduce waste, with only ash being discarded to the landfill (Figure 3b). The Eco-Plant Uonuma has also planned to upgrade the incinerator to guarantee zero emissions from the incineration process. A sanitary landfill is also operated for waste

to completely degrade (Takata *et al.*, 2013). Unlike Mae Chan, Uonuma does not have open dumping or open burning, which could cause pollution. Comparing both study areas, it can be concluded that the ineffective SWM in Mae Chan is mostly caused by inadequate waste treatment that demands more attention and improvements, particularly in landfill management, open dumping, and open burning to reduce pollution in the area. The summary of the comparison on SWM in the study areas is shown in Table 2.



Figure 2. Waste collection points in Uonuma city



(a)

(b)

Figure 3. Open dumping in Mae Chan (a) and waste treatment and disposal at Eco-Plant Uonuma (b)



Figure 4. Rice straw is dried before using as mulch to prevent surface runoff.

Table 2. Comparison between Thai and Japanese waste management systems based on this study

Waste management activities	Japan	Thailand
Source Reduction	1.Structured educational programs and regulations highlight the principles of '3Rs' and producer responsibility.	2.The '3Rs' is merely a collaborative campaign, lacking continuous implementation and often practiced only in certain areas.
Waste Sorting and Recycling	1.Waste categorization prioritizes separation for recycling, with very detailed sorting based on the types of waste. Waste bins are suitable and can communicate clearly to ensure public understanding of the types of waste that should be placed in them, such as combustible waste, non-combustible waste, paper, metal cans, and PET bottles. 2.Collection services for recyclable materials and the facilities for processing them are technologically advanced and subject to regulations.	1.Waste is divided into four broad categories: general waste, recyclable waste, organic waste, and hazardous waste. They are sorted by the color of the bins, sometimes without clear indication of which type of waste should be placed in each bin. 2.Recycling still relies on individuals sorting and selling waste to buyers directly. Some buyers also choose only certain recyclable items.
Waste collection and transportation	1.Waste is sorted before being collected according to the scheduled day for each type of waste. 2.The rate of waste collection exceeds 90 %, with the widespread use of compactor trucks, highly mechanized vehicles, and transfer stations.	1.Waste collection follows a designated route every day but does not cover every area. In some areas, waste is collected only once a week. 2.Unlike Japan, waste is not sorted into types before being collected on schedule (sorting is practiced only in certain areas).
Waste treatment	1.Incineration is very common.	1.Waste is deposited into landfills without treatment. 2.Agricultural waste is disposed of through open burning.
Landfilling	1.Due to limited landfill sites, waste must undergo treatment, such as incineration and volume reduction before being deposited into landfills to ensure the minimum daily deposit.	1.Controlled open dump

3.5 Policy and regulations

In 2014, Mae Chan Municipality established a policy promoting waste separation and recycling. While people have been encouraged to separate recyclable waste, especially plastic bottles, paper, and glass before selling them in waste markets through waste collection shops or dealers, the policy is not mandatory, and there are no penalties for non-compliance. In terms of open burning in Mae Chan District, although there are regulations specifying dates and duration for open burning, as well as penalty fees, some individuals still perform illegal, both intentionally and unintentionally since it is a cheaper and quicker method for disposing of agricultural waste. More than 80% of rice and corn farmers in Chiang Rai Province still dispose of agricultural waste by burning (Adeleke *et al.*, 2017). Therefore, the municipality should strengthen their surveillance to penalize those who violate the regulations and recommend a better solution for agricultural waste recycling or disposal. In Uonuma City, the Eco-plant Uonuma was established solely for waste management; hence, effective waste management is ensured. The Japanese waste management policies, including fees and the implementation of the 3Rs (Reduce, Reuse, and Recycle), as well as fines for waste dumping and burning, are also strictly enforced (Aldieri *et al.*, 2019). Moreover, clear instructions on waste management are provided to residents, as illustrated in Figure 5a. In Mae Chan District, there were only awareness campaigns regarding the 3Rs (Mae Chan Subdistrict Administrative Organization, 2018). This contrasts with Japan, where the 3Rs are established as legislation and policies (Recycling Promotion Division, 2010). Therefore, if policies and regulations become more stringent, people may become more committed to SWM duties such as waste sorting and the 3Rs principles. Central and local governments, environmental NGOs, and mass media should continuously enhance public awareness of SWM through their policies, practices, and operations (Hotta, 2014). From the comparison between both study areas, it is suggested that lenient

surveillance for policy violations and the absence of clear instructions on waste management, particularly for agricultural waste, played a vital role in making SWM in Mae Chan District less effective than in Uonuma City.

However, in 2020, the Mae Chan Subdistrict Administrative Organization (SAO) launched a project promoting waste separation, specifying waste collection and disposal by adapting concepts from Japan (Bangkokbiznews, 2020; Mae Chan Subdistrict Administrative Organization, 2023). The project was initiated in response to an increase in household waste, such as plastic packaging, leading to the near-full capacity of landfills in the area. The instructions on waste management are depicted in Figure 5b. The project was also implemented during the COVID-19 pandemic with a surge in waste disposal in landfills. Due to the specified categorization of waste for daily collection, the quantity of waste sent to landfills has been reduced, and waste is now more effectively utilized (Mae Chan Subdistrict Administrative Organization, 2022). This achievement demonstrates that a successful SWM system can be achieved through the consistent promotion of clear instructions and policies by related authorities.

Learning from Uonuma City, where successful SWM is greatly attributed to effective policies and regulations, three key points can be outlined to enhance waste management in Mae Chan, starting at the household level. The first point involves consistently promoting the 3Rs principles to reduce the daily volume of waste sent to landfills. As suggested by Kaza *et al.* (2018), overcoming municipal solid waste problems relies on increasing reuse, recycling, and recovery rates. For instance, the use of plastic bags should be reduced, and recycling of materials like rice straw should be encouraged (Wichai-utcha & Chavalparit, 2019). Another point is the application of fees and fines for waste management. Local governments should mandate waste management service fees for residents and impose fines or penalties for non-compliance with SWM policies and regulations. Lastly, providing clear instructions on waste

management, especially for agricultural waste, is essential. Effective instruction should cover waste categorization and sorting, waste collection schedules, as well as details on fees, fines, and penalties. These three points, promoting the 3Rs principles, fee and fine requirements, and comprehensive waste management instructions, are fundamental in Uonuma's SWM but not completely featured in Mae Chan's SWM. Therefore, the guideline focusing on these aspects can be useful for improving SWM in Mae Chan.

In terms of limitations in this study, it is widely known that effective waste management also relies on cooperation from the public or waste generators. However, this research did not explore the knowledge, attitudes, or behaviors of the people in the areas. This omission may limit the study to a comparison of systemic administration of waste management practices only. Hence, additional research focusing on the knowledge, attitudes, or behaviors of the community in waste management could enhance the completeness of study outcomes.



(a) Uomuna city

ตารางการเก็บขยะของเทศบาลตำบลแม่เงิน
"แยกเป็น ทิ้งถูก เก็บหมด ลดขยะ"

วันจันทร์ วันพฤหัสบดี จัดเก็บขยะดังนี้	วันอังคาร วันศุกร์ จัดเก็บขยะที่ย่อยสลายได้	วันพุธ วันเสาร์ จัดเก็บขยะรีไซเคิลเงิน	ทุกวันที 1 ของเดือน จัดเก็บขยะอันตรายเงิน
<p>หมอนเก่า เสื้อผ้าเก่า กระดาดขิงขวย ฉานนามับ ก้นบุหรี่ แพนมเฟิส โฟม พอยท์อาหาร</p>	<p>กระดาษ ก้างปลา เปลือกไข่ กระดก ใบตอง กิ่งไม้ เปลือกผลไม้ เศษอาหาร เศษผัก/จากพืชใบไม้</p>	<p>เหล็ก ทองแดง/ทองเหลือง พลาสติก ยางรถยนต์ กระป๋องทุกชนิด ไส้รวมกันใหญ่ ถุงขนมและถุงกาแฟ ไส้รวมกันใหญ่ ถุงพลาสติกทุกประเภท ไส้รวมกัน 1 ถุง กล่องนม กล่องน้ำดื่ม ไส้รวมกัน 1 ถุง</p>	<p>หลอดไฟ กระดาษ แบตเตอรี่ ถ่านไฟฉาย อุปกรณ์อิเล็กทรอนิกส์ กระป๋องปรอท และภาชนะบรรจุสารอันตราย</p>

ไม่แยกขยะ ทั้งชนิดวัน ขยะจะไม่ได้เก็บทำให้มีขยะตกค้าง

ข้อควรปฏิบัติ

๑. ให้นำขยะใส่ถุงหรือใส่ภาชนะให้จัดเก็บวันละ ๑ ประเภทเท่านั้น
 ๒. ขยะชิ้นใหญ่ หรือขยะที่มีจำนวนมาก เช่น กิ่งไม้ เศษปูน หิน ทราย ทุเรียน ไข่ไก่ ให้แจ้งที่กองสาธารณสุขและสิ่งแวดล้อม เทศบาลตำบลแม่เงิน โทร ๐๕๓๒-๖๒๒๖๖๖๖๖ ต่อ ๑๑๑๑๑ เพื่อจัดเก็บทุกวันพุธที่ ๒ และ ๔ ของเดือน

(b) Mae Chan Subdistrict

Figure 5. Guidelines for waste collection and separation of (a) Uonuma city (b) Mae Chan District

Learning from Uonuma City, where successful SWM is greatly attributed to effective policies and regulations, three key points can be outlined to enhance waste management in Mae Chan, starting at the household level. The first point involves consistently promoting the 3Rs principles to reduce the daily volume of waste sent to landfills. As suggested by Kaza *et al.* (2018), overcoming municipal solid waste problems relies on increasing reuse, recycling, and recovery rates. For instance, the use of plastic bags should be reduced, and recycling of materials like rice straw should be encouraged (Wichai-utcha & Chavalparit, 2019). Another point is the application of fees and fines for waste management. Local governments should mandate waste management service fees for residents and impose fines or penalties for non-compliance with SWM policies and regulations. Lastly, providing clear instructions on waste management, especially for agricultural waste, is essential. Effective instruction should cover waste categorization and sorting, waste collection schedules, as well as details on fees, fines, and penalties. These three points, promoting the 3Rs principles, fee and fine requirements, and comprehensive waste management instructions, are fundamental in Uonuma's SWM but not completely featured in Mae Chan's SWM. Therefore, the guideline focusing on these aspects can be useful for improving SWM in Mae Chan.

In terms of limitations in this study, it is widely known that effective waste management also relies on cooperation from the public or waste generators. However, this research did not explore the knowledge, attitudes, or behaviors of the people in the areas. This omission may limit the study to a comparison of systemic administration of waste management practices only. Hence, additional research focusing on the knowledge, attitudes, or behaviors of the community in waste management could enhance the completeness of study outcomes.

4. Conclusion

Urbanization and the tourism have been the key factors behind the significant increase in waste generation in Mae Chan District, Chiang Rai, Thailand. The solid waste management (SWM) in Mae Chan has been less effective and requires improvements. Japan, renowned for its successful SWM, could serve as an excellent model for Mae Chan. Due to the similarities in topography and agricultural activities, this study compared SWM in Mae Chan District and Uonuma City in Japan. The goal was to identify factors contributing to the effectiveness or ineffectiveness of SWM in both areas and suggest suitable techniques from Uonuma for implementation in Mae Chan. The findings revealed that SWM in Uonuma was more efficiently organized than in Mae Chan. While waste generation and composition are similar in both areas, there are slight differences in waste categories and sorting since Japan has combustible and incombustible categories, with incineration commonly used for waste disposal. However, those aspects are not necessarily the main reasons for the less effective SWM in Mae Chan. The ineffectiveness is more likely caused by inadequate and disorganized waste collection and transportation, leading to open dumping. The lack of cooperation and proper operation of in waste treatment and disposal also played a part, especially for landfill and open burning. Additionally, the lenient surveillance of policy and regulations violation encourages open dumping and open burning. To apply Uonuma's SWM techniques to Mae Chan, priority should be given to the impactful factors making the SWM in Uonuma effective, including a well-organized waste collection and treatment system and the strict penalties for policy and regulations violations. Promoting the 3Rs principles and providing instructions on SWM, especially for agricultural waste, are also recommended for the ongoing improvement of SWM in Mae Chan.

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