A Study of Municipal Solid Waste Management Practices in Khuean Ubolratana Subdistrict, Khon Kaen, Thailand.

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An Interactive Science and Social Project by

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Abstract

This report is a comprehensive study of municipal solid waste (MSW) management practices in the Khuean Ubolratana Subdistrict. Through interviews with officials and residents, valuable insights into the current waste management practices were gathered. The report delves into the existing MSW protocols, examining how they are implemented by local authorities and perceived by the community. The study aims to contribute essential knowledge for understanding the dynamics of waste management in the subdistrict, with the ultimate goal of identifying areas for improvement and proposing recommendations for a more effective and sustainable waste management system.

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Executive Summary

Background

The increasing quantity and complexity of waste from our modern lifestyle pose significant environmental and public health challenges. Globally, approximately 11.2 billion tons of solid waste are annually collected, with the decomposition of organic waste contributing to roughly 5 percent of the world's greenhouse gas emissions. However, the concern extends beyond the sheer volume of waste; inadequate waste management practices, ranging from absent collection systems to inefficient disposal methods, give rise to issues such as air pollution and contamination of water and soil. Open and unsanitary landfills further exacerbate problems by polluting drinking water sources, fostering infections, and facilitating the transmission of diseases (UNEP, n.d). Our sponsor, The Ubolratana Hospital Foundation, saw inadequate waste management in Khuean Ubolratana Subdistrict and wanted to investigate the problem and find opportunities to improve it. This project focused on understanding the waste management system within Khuean Ubolratana Subdistrict.

Project Overview

This project aimed to understand the waste management system within Khuen Ubolratana Subdistrict under the responsibility of two local government organizations, the Subdistrict Municipality (MUNI) and the Subdistrict Administrative Organization (SAO). The goal was to identify the causes of the waste problems and propose possible recommendations for improving waste management in the subdistrict. To accomplish the goal, three objectives were set:

(1) Understand the waste management system of the Local Administrative Organizations.
(2) Compare the current system with the protocol and identify the root causes of the problems.
(3) Provide practical recommendations to improve the waste management system for Khuean Ubolratana Subdistrict

Methods

Various research methods were used to accomplish the project's objectives. To achieve the first objective, the team interviewed the two government organizations, the MUNI and SAO. We gathered information on the current waste management systems and protocols, which we later analyzed to create flowcharts for the MSW Processes. These flowcharts helped us visually observe any deviation in the waste management system's processes at sites.

Secondly, The team interviewed the community members and directly observed eight chosen areas within the subdistrict during the fieldwork. The team aimed to better understand waste management practices in each area based on different factors. Once done, the team made another type of MSW Process Analysis flowchart along with Map Analysis and Thematic Coding Analysis to determine the level of upkeep in waste management proposed by the responsible officials and identify areas that can be improved.

To look for achievable recommendations for the Khuean Ubolratana Subdistrict, we visited organizations well-known for their achievements in reaching good waste management goals: Roong Aroon School, the Pollution Control Department (PCD), and Chula Zero Waste. The purpose was to learn more about practical waste management ideas and how they can be applied in Khuean Ubolratana Subdistrict.

Finding

The analysis of data determined five findings:

Finding 1 Official waste management protocols simplified as flowcharts and the current problems according to them

The waste management protocols of the Khuean Ubolratana Subdistrict, administered by the MUNI and SAO, face notable challenges and potential problems. MUNI's protocol emphasizes on-site waste management, sorting, and utilization following the 3R concept to minimize unsorted waste sent to the Waste-to-energy (WTE) plant. However, there are shortcomings. While MUNI encourages recycling through initiatives like the "Waste Bank," community participation may be lacking due to insufficient incentives. Moreover, hazardous waste collection occurs only annually, posing risks in terms of storage and potential environmental hazards. Additionally, the absence of a waste transfer station hampers further segregation after collection, potentially affecting waste management efficiency.

The SAO protocol shares similarities with MUNI but needs a proper waste disposal site, resulting in no waste collection services in most areas except during special events. This absence poses significant environmental and health risks, including pollution, contamination of soil and water bodies, and pest attraction. Economic development and tourism may also suffer due to unsightly waste accumulation.

Finding 2 Geographical insights of Khuean Ubolratana Subdistrict and the effects on waste management of the officials

The map analysis of Khuean Ubolratana Subdistrict illustrates the proximity and distribution of MUNI and SAO sites, highlighting differences in population density and waste management challenges. Despite MUNI's smaller area, it sustains a higher population density, leading to concentrated waste accumulation in certain spots and logistical challenges in transporting waste to the distant WTE plant. In contrast, despite its more extensive area, SAO maintains a rural society with a dispersed population and agricultural focus, influencing waste composition. Infrastructure layout also affects waste accumulation, with areas like Ubolratana Dam being less densely populated and showing better waste management practices than densely packed areas like Bang Saen Song, necessitating extra attention. Addressing these spatial and demographic disparities is crucial for implementing effective waste management strategies in the Subdistrict.

Finding 3 Thematic analysis led to an overview of barriers to effective municipal waste management in the Khuean Ubolratana Subdistrict.

The thematic analysis based on 31 interviews conducted across eight sites in both the MUNI and SAO, categorized the waste issue in Khuean Ubolratana Subdistrict area into 6 themes as follows:

(1) Unregistered residents are beyond the MSW budget covered by the local government organizations.

(2) Ineffective waste management processes encompassing both waste management services provided by authorities and on-site residential sites.

(3) Civic waste management behavior and participation, focusing on observable locals' behaviors noted by the researchers.

(4) Public awareness and attitude are related to the discernible mindset of the locals regarding waste management.

(5) Lack of Resources refers to insufficient budget and human resources.

(6) Bureaucratic constraints occur within the authorities.

Finding 4 Waste situations recurring in Khuen Ubolratana Subdistrict were identified, indicating where the recommendations should be provided.

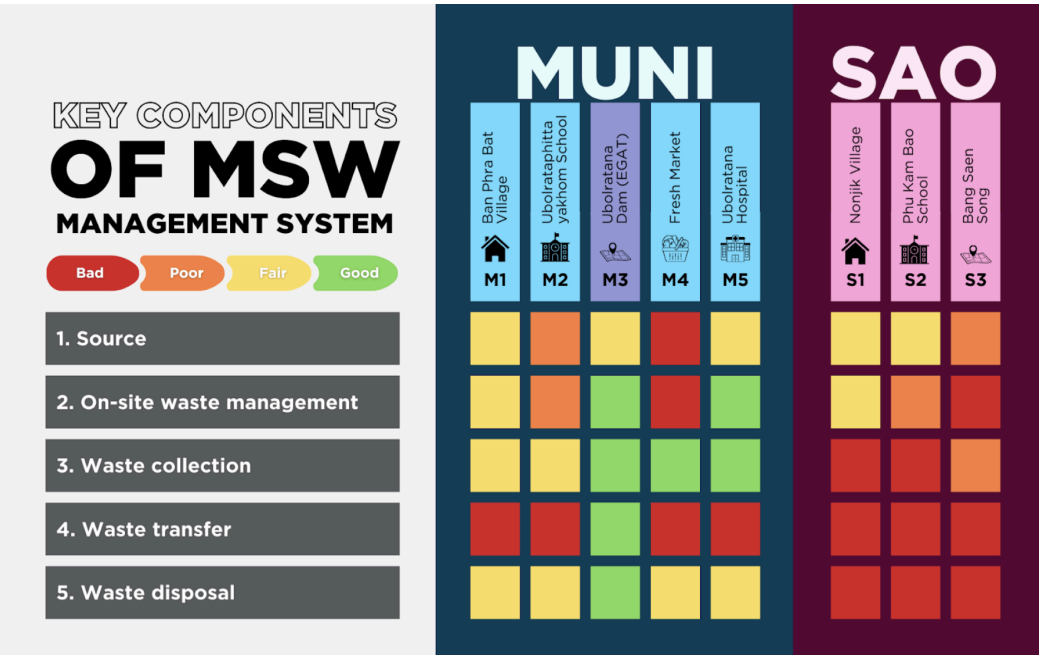


Figure 1. Key Components of MSW Management System

Thematic coding analysis and direct observation of waste issues in Khuean Ubolratana Subdistrict identified challenges across eight sites. Waste situations were categorized by MSW management components, with MUNI (blue) and SAO (pink) areas highlighted separately. Notably, waste management at M3 (Ubolratana Dam) was represented in purple due to management by EGAT despite MUNI jurisdiction. Color codes denoted red for bad status, orange for poor condition, yellow for fair situation, and green for good practice, indicating varying levels of waste management effectiveness.

Finding 4.1 Densely populated areas overseen by MUNI and SAO are facing challenges with source and on-site waste management.

Hot spots in Khuean Ubolratana Subdistrict, like M2 (Ubolrataphittayakhom School), M4 (the fresh market), and S3 (Bang Saen Song), face significant waste accumulation due to high population density. Despite generating large amounts of waste, effective waste management is lacking, leading to subsequent challenges. M2, with over 1,300 students, is rated orange, indicating a capacity-exceeding waste volume. M4, the district's main fresh market, faces a critical red rating due to substantial waste generation and out-of-area dumping issues. SAO-managed S3, a bustling area popular among tourists, also struggles with waste accumulation, earning an orange rating. These findings underscore the urgent need for more effective waste management plans to address the substantial waste volumes in MUNI and SAO-managed areas.

Finding 4.2 Ineffective waste segregation practices occur in MUNI, in contrast with SAO.

In Khuean Ubolratana Subdistrict, community involvement in waste segregation efforts is low, despite some initiatives in places like M1 (Ban Phra Bat Village) and M5 (Ubolratana Hospital). At M2 (Ubolrataphittayakhom School), although canteen food waste is effectively processed into fertilizers, overall waste management needs to be improved. Attempts at waste bank policies are hindered by limited space and moderate community participation. M4 (Fresh Market) faces critical waste management challenges, with insufficient sorting and mixing of waste types exacerbating the issue. Sites with high waste accumulation struggle with on-site management, while SAO shows better segregation practices due to effective plans and village leadership, as seen in S1 (Ban Nonjik Village). SAO's waste bank policy incentivizes community participation, with organic waste repurposed for agricultural use. MUNI is adopting similar policies but needs help managing organic waste at M4. Overall, there is a need for enhanced community involvement and effective waste management plans to address waste segregation challenges effectively.

Finding 4.3 Improper waste disposal methods, such as open-air burning, are commonly practiced in SAO.

Improper waste disposal methods, notably open-air burning, are widespread in SAO communities, with residents and officials participating. The absence of proper waste disposal sites exacerbates the issue, leading to waste management by residents. Agricultural waste is also disposed of through burning, which locals consider convenient. Other improper methods include a lack of waste containers and dumping in public areas due to non-compliance with waste management protocols. Similar practices occur in MUNI but to a lesser extent. These practices contribute to air pollution, health risks, greenhouse gas emissions, and environmental degradation. Addressing these issues is only possible with proper waste disposal sites, emphasizing the need for immediate action and exploring alternative solutions.

Finding 4.4 Waste disposal sites directly impacts the waste collection efforts in both MUNI and SAO.

In Khuean Ubolratana Subdistrict, the absence of a shared waste disposal site between MUNI and SAO poses a significant challenge. MUNI has a contract with a waste-to-energy plant but struggles with insufficient capacity, while SAO lacks a proper disposal site. This leads to strict control over waste collection quotas, resulting in fixed schedules and inadequate services for areas like M2 (Ubolrataphittayakhom School). Open-air burning is employed to manage excess waste. In M1 (Ban Phra Bat Village), inadequate waste collection services lead to improper disposal practices. Similarly, SAO faces challenges due to the need for disposal infrastructure, resulting in widespread improper waste disposal. Thus, establishing a proper disposal site with sufficient capacity is essential for effective waste collection and reducing improper disposal practices.

Finding 4.5 Ubolratana Hospital plays a significant role in disposing of infectious waste within MUNI.

M5 (Ubolratana Hospital) manages infectious waste within MUNI using its incinerator. However, the incinerator should perform better, so as not to cause pollution and potential health risks. Outsourcing to specialized service providers is not feasible due to the hospital's remote location and associated higher costs. Consequently, the hospital continues to handle infectious waste internally despite the limitations of its incinerator.

Finding 4.6 The waste management system at Ubolratana Dam is highly effective.

The Ubolratana Dam, managed by EGAT, excels in waste management due to adequate resources and earning green ratings across key components. Strategic waste segregation bins, effective management of various waste streams, and daily collection services highlight its exemplary practices. The absence of waste transfer stations in MUNI and SAO is noted. The dam's success offers a model for broader waste management improvement, showcasing the feasibility of replicating its methods in other areas for enhanced waste management practices.

Finding 4.7 Lack of resources and bureaucratic constraints are the significant challenges in improving the waste management system in MUNI

Thematic analysis highlighted "Lack of resources" and "Bureaucratic constraints" in MUNI, hindering waste management progress. Inadequate budget, manpower, and infrastructure impede program development, with staffing issues affecting policy implementation like the EM fertilizer policy. MUNI's procurement of a low-quality garbage truck due to organizational regulations further reflects bureaucratic constraints. While not explicitly stated, SAO likely faces similar challenges given its shared governance and environmental context. Collaborative efforts between MUNI and SAO are vital to address resource shortages and bureaucratic barriers, fostering sustainable waste management strategies.

Finding 5 Key findings from interviewing waste-related organizations and their implications to the case in Khuean Ubolratana Subdistrict.

The team researched waste management policies and practices in Thailand, focusing on insights from three key sources: the Pollution Control Department, Rung Aroon School, and Chulalongkorn University Zero Waste (Chula Zero Waste). The Pollution Control Department taught us the importance of upstream waste management and the need for eco-friendly product design to minimize waste generation. PCD emphasized incentivizing proper waste management rather than solely penalizing improper disposal. Rung Aroon School provided valuable lessons in on-site waste management, including sorting recyclable items, composting food scraps, and treating water before returning it to nature. The school emphasized community involvement and made waste management practices accessible to all. Chula Zero Waste at Chulalongkorn University showcased innovative programs such as incentivizing reusable bottle use and implementing detailed waste segregation bins across

campus. They highlighted the significance of fostering a proper waste management mindset among students and staff. These insights highlighted the importance of proactive waste management strategies, community involvement, and innovative initiatives to promote sustainability. By implementing lessons learned from these sources, particularly in incentivizing eco-friendly behaviors and fostering community engagement, the team aims to improve waste management practices in Khuean Ubolratana Subdistrict and beyonds.

Recommendations

The analysis of waste management systems in Khuean Ubolratana Subdistrict reveals challenges such as deficient infrastructure, inadequate segregation practices, and improper disposal methods overseen by MUNI and SAO. SWOT analyses were conducted to assess internal capabilities and external factors. Waste collection, contingent on disposal infrastructure, is a recurring issue, particularly in SAO, where both components are rated red. MUNI currently relies on an out-of-area contractor for waste collection until a local WTE plant is constructed. Recommendations primarily target source management, on-site practices, and waste transfer to address recurring issues until local infrastructure improvements are made. These recommendations offer various options for officials to enhance waste management practices comprehensively.

Recommendation 1 Tackling the influx of out-of-area trash from commuters

Intentionally dumping out-of-area trash near Khuean Ubolratana Subdistrict fresh market has strained MUNI's waste management resources and local waste quota. This issue originates from local households initially disposing of trash on streets to deter scavenging dogs, resulting in a mixture of organic waste. Recommendations propose on-site waste sorting to encourage locals to retain trash at home, thus reducing the out-of-area waste dumping. Concurrent public relations efforts targeting locals and commuters are vital, emphasizing proper waste disposal and discouraging street dumping. With assistance from village health volunteers, visible signage and direct communication can raise awareness. Using successful strategies such as the "Big Cleaning" approach, thorough cleanups coupled with community education can foster compliance and mitigate the out-of-area trash problem. Implementing these measures, including a comprehensive cleanup of the area and surroundings, is essential to alleviate the issue effectively, as demonstrated in the case study of Ban Chum Het in Mueang Buri Ram District (Thai PBS, 2019).

Recommendation 2 Prevention of single-use plastic

Waste accumulation in hotspot areas poses challenges to waste management, but reducing single-use plastics can mitigate this. Insights from Chula Zero Waste's interview reveal that targeting single-use plastics can notably decrease waste volume. By eliminating free single-use plastic bags and charging for them, Chula Zero Waste achieved a 90% reduction in usage. MUNI and SAO can replicate this success by implementing similar policies. To adapt to semi-rural settings, promoting locally available natural materials or encouraging reusable bags through public outreach can enhance the strategy's effectiveness.

Recommendation 3 Public relations in promoting public waste segregation

Improving on-site waste management at the market in MUNI and restaurants in Bang Saen Song requires effective waste segregation procedures. Vendors must be educated on the importance and process of waste segregation, ensuring practical and time-efficient methods. Each vendor should focus on separating organic waste, using clearly labeled green bags for consistency and convenience. MUNI and SAO can collect the trash bags conveniently, with black bags going to waste-to-energy facilities and green bags containing organic waste for further processing. Promoting the importance of waste sorting through various channels such as social media, local newspapers, and community bulletin boards can enhance awareness. Emphasizing the environmental benefits of waste segregation, such as reducing pollution and fostering a healthier community, can encourage participation. Additionally, efficient waste segregation can alleviate the out-of-area trash problem, resulting in a cleaner environment overall.

Recommendation 4 Employment of waste segregation staff to utilize components of organic waste

Creating job opportunities for waste separation can positively impact the environment and the local community by employing in areas with limited opportunities, thereby reducing poverty. The case of Ban Takli in Nakhon Sawan province exemplifies the importance of such jobs in managing the increasing amounts and types of waste generated annually (Ban Takhli Municipality, 2021). Workers would segregate organic waste collected in green bags, particularly from vendors in markets like MUNI and Bang Saen Song, which predominantly produce organic waste. Organic waste, including food scraps, can be composted to produce nutrient-rich compost for soil enrichment. Additionally, certain food waste materials, like animal bones, can be processed into bone meal fertilizer. The revenue generated from selling valuable waste, such as animal bones, could be reinvested in promoting good practices and purchasing necessary infrastructure like waste bins, contributing to the area's cleanliness and sustainability.

Recommendation 5 Implementing waste transfer station

A waste transfer station managed by MUNI can streamline waste management by sorting collected trash, extracting valuable materials for resale or further use, and safely managing hazardous waste. This facility ensures compliance with regulations and mitigates environmental risks. Additionally, it maximizes waste sorting before sending it to the WTE plant. Expanding the station's scope to process SAO's waste could further enhance its productivity and alleviate waste issues in SAO. Key considerations for successful implementation include centralizing the station's location along waste collection routes to minimize transportation distances and providing adequate staff training for safe waste transfer operations.

Recommendation 6 Adjusting waste collection routes and implementing MOU for proper waste disposal sites.

In SAO, the absence of waste disposal sites necessitates the establishment of an MOU to address this issue, considering factors such as minimizing distance and processing various types of waste, including agricultural waste, to reduce open-air burning. Conversely, although a WTE plant is accessible in MUNI, its distance poses challenges. Optimizing waste collection routes, tailored schedules, and regular reviews can enhance efficiency, considering the densely packed sites. Improving waste management practices in both areas is crucial to mitigate environmental and health risks associated with improper disposal methods, such as open-air burning.

Executive Summary (Thai)

การบริโภคอุปโภคของมนุษย์ในปัจจุบันก่อให้เกิดปัญหาขยะที่มีความซับซ้อนและมีปริมาณมหาศาล มนุษย์สร้างขยะมากถึง 11.2 พันล้านตันต่อปี ซึ่งก่อให้เกิดก๊าซเรือนกระจกจากการย่อยสลายขององค์ประกอบที่เป็นอินทรีย์วัตถุคิดเป็นร้อยละ 5 ของก๊าซเรือนกระจกทั้งหมด นอกจากนี้แล้วการจัดการขยะที่ไม่ถูกต้องและด้อยประสิทธิภาพยังนำไปสู่ปัญหาด้านสิ่งแวดล้อมและสาธารณสุขอีกมากมาย การใช้หลุมฝังกลบที่ไม่ถูกสุขลักษณะอาจก่อให้เกิดการปนเปื้อนของแหล่งน้ำบริโภค เป็นแหล่งเพาะเชื้อโรคที่ส่งผลกระทบต่อสุขภาพอนามัยของประชาชนในวงกว้าง

โครงงานวิจัยนี้เป็นความร่วมมือระหว่างมูลนิธิโรงพยาบาลอุบลรัตน์จังหวัดขอนแก่น และ ภาควิชาเคมี คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย โดย พญ.ทานทิพย์ ธำรงวรางกูรผู้เห็นว่าระบบการจัดการขยะในพื้นที่ตำบลเขื่อนอุบลรัตน์นั้นด้อยประสิทธิภาพอันส่งผลกระทบต่อสิ่งแวดล้อมและประชาชนในพื้นที่ การค้นหาสาเหตุของปัญหาและมุมมองของประชาชน เพื่อนำข้อมูลมาประมวลใช้ในการปรับปรุงและพัฒนาระบบจัดการขยะของตำบลเขื่อนอุบลรัตน์ อำเภออุบลรัตน์ จังหวัดขอนแก่น จึงเป็นสิ่งที่ควรกระทำโดยเร็วก่อนที่ปัญหาจะบานปลายและมี ผลกระทบรุนแรง

วัตถุประสงค์การวิจัย

คณะผู้วิจัยมีวัตถุประสงค์ที่จะเรียนรู้ระบบการจัดการขยะในพื้นที่ตำบลเขื่อนอุบลรัตน์ ภายใต้ความรับผิดชอบการดูแลขององค์กรปกครองส่วนท้องถิ่น (อปท.) 2 แห่งคือ เทศบาลตำบลเขื่อนอุบลรัตน์ (ทต.) และ องค์การบริหารส่วนตำบลเขื่อนอุบลรัตน์ (อบต.) โดยตั้งเป้าหมายที่จะระบุสาเหตุของการจัดการขยะที่ไม่ถูกต้องเพื่อเสนอแนวทางปรับปรุง โดยคณะผู้วิจัยได้ตั้งวัตถุประสงค์ไว้ 3 ประการ ดังต่อไปนี้

(1) เรียนรู้ระบบ ขั้นตอน วิธีการจัดการขยะขององค์กรปกครองส่วนท้องถิ่นของ ตำบลเขื่อนอุบลรัตน์

(2) เปรียบเทียบการจัดการขยะในพื้นที่กับแผนการจัดการขยะขององค์กรปกครองส่วนท้องถิ่น ทต. และ อบต. เพื่อระบุต้นตอของปัญหาในกระบวนการจัดการขยะในปัจจุบัน

(3) หาแนวทางปรับปรุงการจัดการขยะที่เหมาะสมกับพื้นที่และบริบทสังคมในพื้นที่ตำบลเขื่อนอุบลรัตน์

วิธีดำเนินการวิจัย

คณะผู้วิจัยประยุกต์ใช้ระเบียบวิธีวิจัยทางสังคมศาสตร์หลายวิธีในโครงงานนี้ ในขั้นแรกคณะผู้วิจัยได้สัมภาษณ์องค์กรปกครองส่วนท้องถิ่นของพื้นที่ตำบลเขื่อนอุบลรัตน์ 2 หน่วยงาน ได้แก่ เทศบาลตำบลเขื่อนอุบลรัตน์ (ทต.) และ องค์การบริหารส่วนตำบลเขื่อนอุบล รัตน์ (อบต.) เพื่อเรียนรู้ระบบการจัดการขยะในพื้นที่ความรับผิดชอบของแต่ละหน่วยงาน จากนั้นนำข้อมูลที่ได้ไปสร้างแผนภูมิหลักของกระบวนการจัดการขยะมูลฝอยของ ทต. และ อบต. ตามลำดับ

ในขั้นต่อมาคณะผู้วิจัยใช้การสัมภาษณ์และสังเกตการณ์วิถีชีวิตและกระบวนการจัดการขยะในชุมชน 8 แห่งของตำบลเขื่อนอุบลรัตน์ และได้ประมวลข้อมูลในรูปแผนภูมิของกระบวนการจัดการขยะมูลฝอยของแต่ละพื้นที่และนำไปเปรียบเทียบกับแผนภูมิหลักของระเบียบการจัดการขยะของ ทต. และ อบต. เพื่อระบุประเด็นและปัญหาการจัดการขยะที่เกิดขึ้นจริงในแต่ละชุมชนและบริบทสังคม

ในขั้นสุดท้าย คณะผู้วิจัยได้เยี่ยมชมและสัมภาษณ์หน่วยงานที่ประสบความสำเร็จในการจัดการขยะ ได้แก่ โรงเรียนรุ่งอรุณ กรมควบคุมมลพิษ และ Chula Zero Waste เพื่อเรียนรู้ปัญหาและอุปสรรคของการจัดการขยะในปัจจุบันและแนวทางที่จะก้าวข้ามอุปสรรคเหล่านั้น คณะผู้วิจัยนำข้อมูลที่ได้มาประยุกต์และนำเสนอแนวทางแก้ปัญหาและปรับปรุงการจัดการขยะที่เหมาะสมกับบริบทสังคมในตำบลเขื่อนอุบลรัตน์

ผลการศึกษา

1. การสร้างแผนภูมิหลักของกระบวนการจัดการขยะมูลฝอยของ ทต. และ อบต.

การจัดการขยะของตำบลเขื่อนอุบลรัตน์ซึ่งบริหารงานโดย ทต. และ อบต. ต้องเผชิญกับความท้าทายและปัญหาหลายอย่างในปัจจุบัน ระบบของ ทต. เน้นการคัดแยกก่อนทิ้งตามแนวคิด 3R เพื่อลดปริมาณขยะก่อนส่งไปกำจัดที่โรงงานไฟฟ้าพลังงานขยะปลายทาง คณะผู้วิจัยพบข้อบกพร่องในแนวปฏิบัติหลายประเด็นจากการศึกษาแผนภูมิระบบจัดการขยะทั้งสององค์กร เช่น ในส่วนของ ทต. โครงการ "ธนาคารขยะ" ขาดการมีส่วนร่วมของชุมชน การรวบรวมของเสียอันตรายในพื้นที่ปีละ 1 ครั้งนั้นก่อให้เกิดความเสี่ยงในการรั่วไหลสู่สิ่งแวดล้อม นอกจากนี้การขาดสถานีกลางเพื่อเก็บ/แยกขยะก่อนการกำจัดนั้นส่งผลกระทบต่อประสิทธิภาพการจัดการขยะโดยรวมอีกด้วย

ระบบการจัดการขยะของ อบต. นั้นคล้ายคลึงกับระบบของ ทต. เกือบจะทุกประเด็น ระบบของ อบต. ขาดสถานที่กำจัดขยะปลายทางและไม่มีบริการเก็บขยะในพื้นที่ยกเว้นในช่วงเทศกาลสำคัญ ขั้นตอนที่ขาดไปนี้ก่อให้เกิดการปนเปื้อนในสิ่งแวดล้อมและมีผลกระทบต่อสุขภาพของประชาชน อีกทั้งยังดึงดูดสัตว์จรจัดและปรสิตอันส่งผลเสียต่อสุขอนามัย เศรษฐกิจ และการท่องเที่ยวในพื้นที่

2.ข้อมูลเชิงภูมิศาสตร์ของตำบลเขื่อนอุบลรัตน์และการจัดการขยะเชิงประชากรและเชิงภูมิศาสตร์

การวิเคราะห์แผนที่ของตำบลเขื่อนอุบลรัตน์แสดงให้เห็นถึงความแตกต่างของเขตอำนาจการปกครอง ทต. มีขนาดเล็กแต่มีความหนาแน่นของประชากรสูง นำไปสู่การสะสมของขยะมูลฝอยในปริมาณมากในบางพื้นที่ ปริมาณขยะในพื้นที่ ทต. เป็นปัญหาใหญ่ของ การกำจัดขยะปลายทางผ่านโรงไฟฟ้าพลังงานขยะนอกพื้นที่ทั้งในแง่โควต้ารายเดือนและการขนส่ง ในบริบทของ อบต. นั้นเป็นการบริหารพื้นที่ชนบทขนาดใหญ่มีประชากรกระจัดกระจาย ประชาชนส่วนใหญ่ประกอบอาชีพเกษตรกรรม ดังนั้นองค์ประกอบของขยะและบริบทสังคม ของ อบต. จึงต่างจาก ทต. โดยสิ้นเชิง ตำบลเขื่อนอุบลรัตน์มีสถานที่ท่องเที่ยวสำคัญสองแห่งคือ เขื่อนอุบลรัตน์ซึ่งมีการวางผังเมืองที่ดี ไม่หนาแน่น และมีแนวทางการจัดการขยะที่ดี บางแสนสองในพื้นที่รับผิดชอบของ อบต. เป็นสถานที่ท่องเที่ยวยอดนิยม เป็นชุมชนหนาแน่น และไม่มีการจัดการขยะใดๆ จำเป็นต้องมีการแก้ไขโดยเร่งด่วน การนำข้อมูลทางภูมิศาสตร์มาประกอบกับบริบททางสังคมจะช่วยให้การสร้างกลยุทธ์ในการจัดการขยะมีประสิทธิภาพ

3. ปัญหาของการบริการจัดการขยะในปัจจุบันของตำบลเขื่อนอุบลรัตน์

คณะผู้วิจัยได้สกัดแนวความคิดหรือธีม (Thematic analysis) เพื่อเข้าใจมุมมองของประชาชนในตำบลเขื่อนอุบลรัตน์เกี่ยวกับปัญหาการบริหารจัดการขยะในปัจจุบันโดยการสัมภาษณ์ 31 ครั้ง ใน 8 พื้นที่ของตำบลเขื่อนอุบลรัตน์ทั้งในเขต ทต. และ อบต. พบประเด็นหลัก 6 ประเด็น ดังต่อไปนี้:

(1) **ผู้อยู่อาศัยนอกทะเบียนราษฎรของพื้นที่** งบประมาณจากหน่วยงานราชการไม่ครอบคลุมประชากรกลุ่มนี้ทำให้การบริหารจัดการขยะไม่มีประสิทธิภาพ

(2) **กระบวนการจัดการขยะด้อยประสิทธิภาพ** ทั้งบริการจัดการขยะของหน่วยงานราชการ และบ้านเรือน

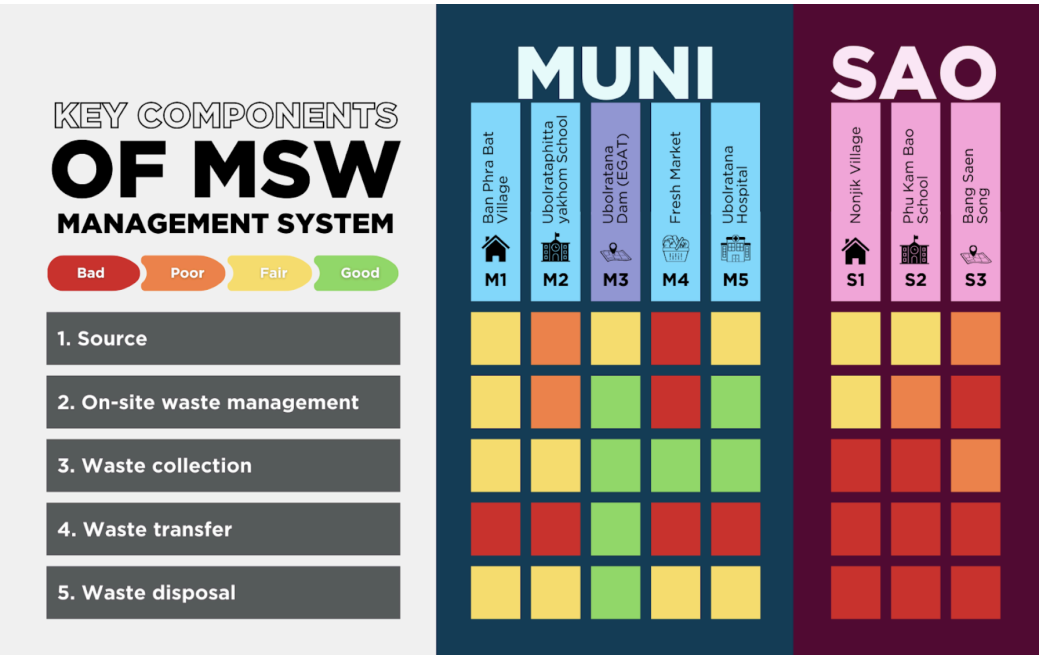
(3) **พฤติกรรมและการมีส่วนร่วมในการบริหารจัดการขยะชุมชน** ประชาชนส่วนมากยังขาดความเข้าใจในการทิ้งขยะที่ถูกต้องและไม่ร่วมมือกับองค์กรบริหารส่วนภูมิภาค

(4) **การตระหนักรู้และทัศนคติในการจัดการขยะ** กรอบความคิดเรื่องการจัดการขยะของคนในท้องถิ่นและทัศนคติโดยรวมยังด้อยกว่ามาตรฐาน

(5) **การขาดแคลนทรัพยากร** การจัดสรรทรัพยากรและบุคคลากรด้านการบริหารจัดการขยะยังไม่เหมาะสมและไม่เพียงพอ

(6) **ข้อจำกัดของหน่วยงานราชการ** หน่วยงานราชการดำเนินการในกรอบที่รัฐบาลตั้งไว้ขาดความคล่องแคล่วในการปรับรูปแบบการดำเนินงาน

4. ปัญหาซ้ำซากของการบริการจัดการขยะชุมชนในตำบลเขื่อนอุบลรัตน์ และจุดที่ควรแก้ไข



รูปภาพที่ 1. องค์ประกอบหลักของระบบการจัดการขยะมูลฝอยและสถานการณ์

คณะผู้วิจัยได้นำประเด็นปัญหาของการจัดการขยะในพื้นที่ตำบลเขื่อนอุบลรัตน์มาจำแนกตามขั้นตอนของกระบวนการบริการจัดการขยะที่พบใน 8 พื้นที่ โดยใช้สีน้ำเงินแสดงพื้นที่ ในเขต ทต. และ สีชมพูแสดงพื้นที่ในเขต อบต.การจัดการขยะที่ M3 (เขื่อนอุบลรัตน์) จะแสดงเป็นสีม่วง เนื่องจากอยู่ภายใต้การดูแลของ กฟผ. ประสิทธิภาพของขั้นตอนการบริหารจัดการขยะจะระบุดังนี้ สีแดงแสดงสถานะวิกฤต สีส้มแสดงสถานะใกล้วิกฤต สีเหลืองหมายถึงพอใช้ และสีเขียวหมายถึงดี

4.1 การจัดการขยะไม่เพียงพอในเขตประชาการหนาแน่น

พื้นที่คนพลุกพล่านในตำบลเขื่อนอุบลรัตน์ อาทิเช่น M2 (โรงเรียนอุบลรัตน์พิทยาคม) M4 (ตลาดสด) และ S3 (บางแสนสอง) มีปัญหาการสะสมขยะอย่างมีนัยสำคัญเนื่องจากมีความหนาแน่นของประชากรสูง และขาดการจัดการขยะที่มีประสิทธิภาพ พื้นที่ M2 (โรงเรียนอุบลรัตน์พิทยาคม) ซึ่งมีนักเรียนมากกว่า 1,300 คน มีสถานะใกล้วิกฤตเนื่องจากมีปริมาณขยะในแต่ละวันเกินขีดความสามารถของการกำจัด ส่วน M4 (ตลาดสด) ซึ่งเป็นตลาดสดแห่งเดียวในอำเภออยู่ในสถานะวิกฤตเนื่องจากมีขยะรายวันจำนวนมาก และยังมีการซ้ำเติมจากขยะนอกพื้นที่ด้วย พื้นที่ S3 (บางแสนสอง) ในเขตรับผิดชอบของ อบต. แหล่งท่องเที่ยวยอดนิยมเป็นพื้นที่ใกล้วิกฤตเนื่องจากมีขยะในพื้นที่เป็นจำนวนมาก การวิเคราะห์ปัญหาโดยใช้แผนภูมิดังแสดงในภาพที่ 1 นี้ช่วยให้ผู้วิจัยสามารถระบุ ประเด็น ประเภท ความเร่งด่วนของปัญหา ในการวางแผนปรับปรุงระบบการจัดการขยะ ของ ทต. และ อบต.ให้มีประสิทธิภาพมากขึ้น

4.2 ประชาชนในพื้นที่ อบต. ให้ความร่วมมือในการแยกขยะครัวเรือนดีกว่าประชาชนใน เขตเมือง

การมีส่วนร่วมของชุมชนในการแยกขยะยังมีน้อยในตำบลเขื่อนอุบลรัตน์ อย่างไรก็ดี ได้เริ่มมีการสร้างแนวร่วมในบางพื้นที่ เช่น M1 (หมู่บ้านบ้านพระบาท) M5 (โรงพยาบาลอุบลรัตน์) และ M2 (โรงเรียนอุบลรัตน์พิทยาคม) จะมีการนำเศษอาหารจากโรงอาหารของ M2 ไปผลิตปุ๋ย แต่การจัดการขยะโดยรวมยังไม่เพียงพอ โครงการธนาคารขยะมีข้อจำกัดด้านพื้นที่ใช้สอยและการมีส่วนร่วมของชุมชนไม่เพียงพอ พื้นที่วิกฤต M4 (ตลาดสด) เผชิญปัญหาด้านการคัดแยก ส่งผลให้ปริมาณขยะที่จะต้องกำจัดเพิ่มเป็นทวีคูณ สำหรับพื้นที่มีการสะสมของขยะมูลฝอยในปริมาณสูงและขาดการจัดการขยะที่ดี คณะผู้วิจัยพบว่าพื้นที่ภายใต้การดูแลของ อบต. มีความร่วมมือในการแยกขยะดีกว่าซึ่งเป็นผลของการสร้างมูลค่าเพิ่มให้ขยะรีไซเคิล เช่น พื้นที่ S1 (หมู่บ้าน บ้านโนนจิก) มีผู้นำหมู่บ้านช่วยวางแผนและบริหารธนาคารขยะของหมู่บ้าน นโยบายธนาคารขยะของอบต. นั้นส่งเสริมการมีส่วนร่วมของชุมชน โดยสนับสนุนให้แปลงขยะอินทรีย์ไปใช้ประโยชน์ ทางการเกษตร แม้ว่าเทศบาลที่ใช้หลักการเดียวกันในการลดปริมาณขยะแต่กลับเผชิญกับปัญหาขยะอินทรีย์ที่ M4 (ตลาดสด) คณะผู้วิจัยมีความเห็นว่า ทต. จะต้องส่งเสริมการมีส่วนร่วมของชุมชนในการกำจัดขยะครัวเรือนโดยให้มีการคัดแยกขยะก่อนส่งกำจัดมากขึ้น

4.3 พบการกำจัดขยะด้วยการเผาในที่โล่ง

มีการเผาในที่โล่งอย่างแพร่หลายในเขตพื้นที่อบต. ทั้งในเขตบ้านเรือนและองค์กร การขาดสถานที่กำจัดขยะที่เหมาะสมในเขต อบต. ทำให้ปัญหาการเผาในที่โล่งเพื่อกำจัด ขยะครัวเรือนและขยะเกษตรกรรมรุนแรง การที่ประชาชนในเขต อบต. เลือกการเผา เนื่องจากเป็นวิธีการที่สะดวก การขาดจุดรับขยะสาธารณะและไม่มีถังขยะรวมในพื้นที่ การเผาในที่โล่งพบในเขตเทศบาลเช่นกันแต่เกิดขึ้นในระดับที่น้อยกว่า การเผาในที่โล่งทำให้เกิดมลพิษทางอากาศ เพิ่มความเสี่ยงต่อสุขภาพ สร้างก๊าซเรือนกระจก และทำให้สิ่งแวดล้อมเสื่อมโทรม การจัดการกับปัญหาเหล่านี้เป็นเรื่องยุ่งยากหากไม่มีสถานที่กำจัดขยะที่เหมาะสม การแก้ไขปัญหาการเผาในที่โล่งควรปฏิบัติทันที โดยเริ่มจากการให้บริการจุดรับขยะชุมชนที่เพียงพอและถูกต้องตามหลักการ จากนั้นควรหาแนวทางแก้ไขปัญหาและปรับปรุงระบบโดยเร็วที่สุด

4.4 การขาดบ่อขยะในพื้นที่มีผลกระทบโดยตรงต่อบริการเก็บขยะของ ทต. และ อบต.

การที่บ่อขยะของตำบลเขื่อนอุบลรัตน์ถูกปิดไปทำให้การกำจัดขยะในพื้นที่เป็นไปด้วยความยากลำบาก เทศบาลได้ทำสัญญากับโรงไฟฟ้าพลังงานขยะ (WTE) นอกพื้นที่ ๆ สามารถรับขยะบางส่วนไปกำจัด อย่างไรก็ดีการบริการที่ไม่เพียงพอทำให้ พื้นที่ M1 (หมู่บ้านบ้านพระบาท) และ M2 (โรงเรียนอุบลรัตน์พิทยาคม) จำเป็นต้องใช้การเผาในที่ โล่งและวิธีการอื่นๆ จัดการขยะส่วนเกิน

การขาดสถานที่กำจัดขยะมูลฝอยทำให้ อบต. ต้องควบคุมการเก็บขยะอย่างเข้มงวดและลดความถี่ของบริการ ส่งผลให้เกิดการกำจัดขยะที่ไม่เหมาะสมเป็นวงกว้าง ดังนั้นการจัดตั้งสถานที่กำจัดขยะที่เหมาะสมและเพียงพอเป็นสิ่งที่จำเป็นที่จะลดวิธีการไม่เหมาะสม เช่น การเผาในที่โล่ง

4.5 โรงพยาบาลอุบลรัตน์มีบทบาทสำคัญในการกำจัดขยะติดเชื้อของตำบลเขื่อนอุบลรัตน์

M5 (โรงพยาบาลอุบลรัตน์) จัดการขยะติดเชื้อของโรงพยาบาลและรับขยะติดเชื้อจาก ทต. มาช่วยกำจัดด้วย เตาเผาของโรงพยาบาลที่ใช้อยู่ปัจจุบันมีสภาพทรุดโทรม การสันดาปไม่สมบูรณ์ ก่อให้เกิดมลพิษและความเสี่ยงต่อสุขภาพ แต่โรงพยาบาลขาดงบประมาณจัดจ้างบริการกำจัดขยะติดเชื้อเนื่องจากโรงพยาบาลตั้งอยู่ห่างไกล มีค่าใช้จ่ายในการขนขยะติดเชื้อไปบำบัดสูง เป็นผลให้โรงพยาบาลยังคงต้องจัดการขยะติดเชื้อของตำบลเขื่อนอุบลรัตน์ต่อไป

4.6 ระบบการจัดการขยะของเขื่อนอุบลรัตน์ดีเยี่ยม

เขื่อนอุบลรัตน์อยู่ภายใต้การดูแลของการไฟฟ้าฝ่ายผลิตแห่งประเทศไทย มีความเป็นเลิศในการจัดการขยะทุกด้านจึงได้รับคะแนนสีเขียวทุกขั้นตอนของกระบวนการบริหารจัดการขยะ เช่น มีการคัดแยกขยะอย่างถูกต้องสามารถจัดการแหล่งขยะในพื้นที่ ได้อย่างมีประสิทธิภาพ และมีการรวบรวมขยะรายวัน ระบบการจัดการขยะของเขื่อนอุบลรัตน์ สามารถใช้เป็นต้นแบบและตัวอย่างการบริหารจัดการขยะของตำบลเขื่อนอุบลรัตน์ได้

4.7 งบประมาณสนับสนุนการกำจัดขยะมูลฝอยไม่เพียงพอและข้อจำกัดของหน่วยงานการปกครองส่วนท้องถิ่น

ประเด็นที่มีการกล่าวถึงมากในเขต ทต. คือ "งบประมาณสนับสนุน" และ "ข้อจำกัดตามภารกิจและหน้าที่ของเทศบาลตามพระราชบัญญัติ" เป็นอุปสรรคต่อการพัฒนาการจัดการขยะ การขาดแคลนบุคคลากรที่เหมาะสมทำให้นโยบายต้องหยุดชะงัก เช่น โครงการผลิตปุ๋ย EM จากขยะอินทรีย์ เป็นต้น ข้อกำหนดตามพระราชบัญญัติเทศบาลได้กำหนดขอบเขตหน้าที่ไว้เข้มงวด ทำให้การพัฒนาปรับปรุงระบบบริหารจัดการขยะมูลฝอยและสิ่งปฏิกูลยากลำบาก คณะผู้วิจัยคาดว่า อบต. น่าจะประสบปัญหานี้เช่นกันแม้จะไม่มีการกล่าวถึง ความร่วมมือกันของทั้งสองหน่วยงานในการพัฒนาระบบบริหารจัดการขยะมูลฝอยของตำบลเขื่อนอุบลรัตน์น่าจะเป็นทางออกที่ดีที่สุด โดยทั้งสองหน่วยงานสามารถแบ่งปันทรัพยากรและบุคลากรที่มีในการรักษาความ สะอาด การกำจัดขยะมูลฝอยดูแลทรัพยากรธรรมชาติและสิ่งแวดล้อมของตำบลเขื่อนอุบลรัตน์

5. ตัวอย่างกลยุทธ์เพื่อก้าวข้ามอุปสรรคของการบริหารจัดการขยะในประเทศไทย

คณะผู้วิจัยได้แสวงหาแนวคิด วิธีการ และแนวปฏิบัติ ที่ประสบผลสำเร็จในการลดขยะในชุมชน และเลือกกรณีศึกษา 3 แหล่งได้แก่ กรมควบคุมมลพิษ โรงเรียนรุ่งอรุณ และ โครงการจัดการขยะมูลฝอยและขยะอันตรายในจุฬาลงกรณ์มหาวิทยาลัย Chula Zero Waste กรมควบคุมมลพิษเน้นการจัดการขยะต้นทางและความจำเป็นในการออกแบบผลิตภัณฑ์ต้นทางที่เป็นมิตรกับสิ่งแวดล้อมเพื่อลดการสร้างขยะ ซึ่งกรมควบคุมมลพิษเน้น **"**การสร้างแรงจูงใจใน การจัดการขยะ**"** การเรียนรู้เมื่อทำผิดเป็นบทเรียนสำคัญที่จะก่อให้เกิดการเปลี่ยนแปลงมากกว่าบทลงโทษ โรงเรียนรุ่งอรุณมีระบบการจัดการขยะภายในโรงเรียนที่เข้มข้น มีการคัดแยกวัสดุรีไซเคิลทุกชนิด การทำปุ๋ยหมักเศษอาหารและการบำบัดน้ำเสียก่อนปล่อยคืนสู่ธรรมชาติทางโรงเรียนได้เน้นย้ำถึงความสำคัญของ "การมีส่วนร่วมของชุมชน" และการทำให้ทุกคนสามารถจัดการขยะส่วนตัวได้ หน่วยงาน Chula Zero Waste ของจุฬาลงกรณ์มหาวิทยาลัยใช้ "นวัตกรรม" ในการปรับพฤติกรรมของชุมชน เช่น การส่งเสริมการใช้ขวดแบบใช้ซ้ำได้ และการใช้ถังแยกขยะโดยละเอียดทั่วทั้งมหาวิทยาลัย ทางโครงการให้ความสำคัญต่อการส่งเสริมทัศนคติการจัดการขยะที่เหมาะสมในหมู่นักศึกษาและบุคลากรของมหาวิทยาลัย

ข้อมูลเหล่านี้แสดงถึงความสำคัญของกลยุทธ์ในการจัดการขยะเชิงรุก การมีส่วนร่วมของชุมชน และความริเริ่มเชิงนวัตกรรมเพื่อส่งเสริมความยั่งยืน บทเรียนเหล่านี้สามารถนำมาปรับให้เหมาะสมในบริบทของตำบลเขื่อนอุบลรัตน์เพื่อสร้างแรงจูงใจในการปรับพฤติกรรมให้เป็นมิตรต่อสิ่งแวดล้อมและส่งเสริมการมีส่วนร่วมของชุมชนในการบริหารจัดการขยะในพื้นที่ต่อไป

ข้อสรุปและข้อเสนอแนะ

ผลการวิเคราะห์ระบบการจัดการขยะในตำบลเขื่อนอุบลรัตน์ตามที่บรรยายมาข้างต้นแสดงให้เห็นข้อบกพร่องในโครงสร้างพื้นฐาน การคัดแยกขยะที่ไม่เพียงพอ และการกำจัดขยะโดยวิธีการที่ไม่ถูกต้อง คณะผู้วิจัยได้ใช้วิเคราะห์สภาพแวดล้อมและศักยภาพ (SWOT Analysis) ในการประเมินความสามารถขององค์กรในการแก้ปัญหาขยะในบริบทของพื้นที่บริการเก็บขยะ และวิธีการกำจัดขยะเป็นปัญหาวิกฤตของ อบต. ในปัจจุบัน ทต. ใช้บริการกำจัดขยะนอกพื้นที่ระหว่างการก่อสร้างโรงไฟฟ้าพลังงานขยะชุมชน ในเบื้องต้นคณะผู้วิจัยเสนอให้เพิ่ม การแยกขยะที่แหล่งกำเนิด การแยกขยะที่ถูกต้อง และจัดสถานีขยะกลางเพื่อเก็บขยะมูลฝอยเพื่อลดวิกฤตในปัจจุบันลงจนกว่าจะมีการปรับปรุงโครงสร้างพื้นฐานอย่างเป็นรูปธรรม คณะผู้วิจัยได้รวบรวมแนวทางหลากหลายในการปรับปรุงการจัดการขยะให้มีประสิทธิภาพ

ข้อเสนอแนะที่ 1 ลดขยะอันเกิดจากประชากรแฝงกลางวัน

วัฒนธรรมการนำขยะครัวเรือนมาทิ้งบริเวณตลาดสดตำบลเขื่อนอุบลรัตน์ (M2) ของชุมชนส่งผลต่อประสิทธิภาพของการบริหารจัดการขยะของ ทต. เป็นอย่างมาก ปัญหาเหล่านี้เริ่มต้นจากการทิ้งขยะริมถนนของครัวเรือนในพื้นที่เพื่อป้องกันสัตว์จรจัดเข้าไปขุดคุ้ยในบ้านของตนและปานปลายกลายเป็นพฤติกรรมของประชากรแฝงกลางวัน คณะผู้วิจัยขอเสนอแนะให้มีการแยกขยะในครัวเรือน การแยกขยะอินทรีย์และขยะรีไซเคิลออกจากขยะครัวเรือนก่อนส่งกำจัดผ่านเทศบาลจะช่วยลดปริมาณขยะที่ต้องส่งกำจัดนอกพื้นที่ ขยะอินทรีย์ที่บำบัดเหมาะสมในครัวเรือน และขยะรีไซเคิลที่แยกอย่างถูกต้องจะสะอาดปราศจากกลิ่นไม่พึงประสงค์ และจะไม่มีการรบกวนจากสัตว์และแมลง ทต. ควรประชาสัมพันธ์เรื่องการกำจัดขยะอย่างเหมาะสมด้วย เช่น มีป้ายประชาสัมพันธ์ห้ามทิ้งขยะริมถนน และการประชาสัมพันธ์โดยตรงผ่านอาสาสมัครสาธารณสุขในหมู่บ้านเพื่อสร้างความตระหนักรู้ให้กับประชาชนในพื้นที่ การจัดกิจกรรม “บิ๊กคลีนนิ่ง” ในพื้นที่ควบคู่ไปกับการให้ความรู้แก่ชุมชนเพื่อส่งเสริมการปฏิบัติตามกฎระเบียบอย่างถูกต้องและลดปัญหาขยะนอกพื้นที่ได้ การดำเนินการตามมาตรการเหล่านี้ รวมทั้งการทำความสะอาดพื้นที่และบริเวณโดยรอบเป็นจุดตั้งต้นของการจัดการปัญหาขยะริมถนนอย่างมีประสิทธิภาพ ดังตัวอย่างในกรณีศึกษาบ้านชุมเห็ด อำเภอเมือง จังหวัดบุรีรัมย์ (ไทย พีบีเอส, 2019)

ข้อเสนอแนะที่ 2 ลดการใช้พลาสติกแบบใช้ครั้งเดียว

ตลาดสดเทศบาลตำบลเขื่อนอุบลรัตน์เป็นจุดวิกฤตของการกำจัดขยะในพื้นที่ มีปริมาณขยะรายวันที่เกินโควต้าการกำจัดของเทศบาล องค์ประกอบของขยะในตลาดสดประกอบด้วยขยะอินทรีย์และพลาสติกเป็นหลัก โดยมีการใช้พลาสติกแบบใช้ครั้งเดียวเป็นจำนวนมาก จากกรณีศึกษาของ Chula Zero Waste ที่ประสบความสำเร็จในการลดพลาสติกแบบใช้ครั้งเดียวลง 90% ในร้านค้าของจุฬาลงกรณ์มหาวิทยาลัยผ่านนโยบายการเลิกแจกถุงพลาสติก และเรียกเก็บเงินค่าถุงพลาสติกจากลูกค้า ตำบลเขื่อนอุบลรัตน์สามารถนำกลยุทธ์นี้ไปปรับใช้ในบริบทของตน เช่น ส่งเสริมการใช้บรรจุภัณฑ์ธรรมชาติที่หาได้ในท้องถิ่นแทนบรรจุภัณฑ์พลาสติกประเภทใช้ครั้งเดียว การสนับสนุนการใช้ถุงที่สามารถนำกลับมาใช้ใหม่ โดยเพิ่มการประชาสัมพันธ์ในพื้นที่เพื่อกระตุ้นให้เกิดการเปลี่ยนพฤติกรรม

ข้อเสนอแนะที่ 3 ส่งเสริมการแยกขยะ

การแยกขยะเป็นหัวใจของการลดขยะที่ต้องกำจัดการแยกขยะที่ถูกต้องและมีประสิทธิภาพขึ้นอยู่กับความรู้ของประชาชน ดังนั้นจึงจำเป็นที่จะต้องให้ความรู้ ฝึกซ้อม ลองผิดลองถูก เพื่อปรับปรุงกระบวนการให้เหมาะสมกับบริบทของแต่ละพื้นที่ การจัดการขยะในพื้นที่ตลาดสดเทศบาล และร้านอาหารในบางแสนสองจำเป็นต้องมีกระบวนการคัดแยกขยะที่มีประสิทธิภาพ ผู้ขายต้องเข้าใจขั้นตอนการแยกขยะ ปฏิบัติได้จริง และรวดเร็ว ตัวอย่างเช่น ควรเริ่มด้วยการแยกขยะอินทรีย์ใส่ถุงสีเขียว เพื่อทำให้กระบวนการจัดการขยะรวดเร็วและคล่องตัว เจ้าหน้าที่สามารถรวบรวมถุงสีเขียวออกจากขยะทั่วไปได้รวดเร็ว ขยะในถุงสีเขียว และถุงสีดำสามารถนำไปกำจัดต่อได้อย่างถูกต้อง ควรเพิ่มการรณรงค์และเสริมสร้างความเข้าใจ ในกระบวนการแยกขยะอย่างถูกต้องผ่านโซเชียลมีเดีย หนังสือพิมพ์ท้องถิ่น กระดาน ประชาสัมพันธ์ ภายในชุมชน ระบบเสียงตามสาย โดยอธิบายถึงประโยชน์ของการคัดแยกขยะที่ช่วยลดมลภาวะในสิ่งแวดล้อม และการเสริมสร้างสุขอนามัยชุมชนที่ดีเพื่อชักจูงให้ประชาชนเข้ามามีส่วนร่วมในกิจกรรม การแยกขยะที่ถูกต้องจะลดปริมาณขยะที่ต้องส่งกำจัดลงอย่างมีนัยสำคัญซึ่งจะช่วยบรรเทาปัญหาขยะจากประชากรแฝงกลางวันและส่งผลให้สภาพแวดล้อมโดยรวมสะอาดขึ้นอีกด้วย

ข้อเสนอแนะที่ 4 การจัดจ้างบุคคลากรคัดแยกขยะเพิ่มเติม

จัดโครงการจ้างบุคคลากรแยกขยะเพื่อสร้างโอกาสให้กับคนในพื้นที่เพื่อประโยชน์ต่อสิ่งแวดล้อมและชุมชน ดังกรณีศึกษาของบ้านตาคลี จังหวัดนครสวรรค์ (เทศบาลเมืองตาคลี, 2021) ที่จ้างบุคคลากรใหม่เพื่อรับมือกับปริมาณขยะที่เพิ่มขึ้นทุกปี โดยที่คนงานจะแยกขยะอินทรีย์ใส่ถุงสีเขียวเพื่อความสะดวกในการนำไปแปรรูปต่อไป กรณีศึกษานี้สามารถนำไปประยุกต์ใช้ได้ทั้งใน พื้นที่ตลาดสดเทศบาลและบางแสน สองที่ขยะส่วนใหญ่เป็นขยะอินทรีย์ประเภทเศษอาหารที่สามารถนำไปหมักเป็นดินและปุ๋ยคุณภาพดี ขยะบางชนิด เช่น กระดูกสัตว์ก็สามารถนำไปป่นเป็นปุ๋ยที่อุดมไปด้วยแคลเซียม ดินและปุ๋ยจากการหมักเศษอาหารสามารถขายได้ราคาดี องค์กรสามารถนำกำไรจากการขายปุ๋ยไปใช้เป็นทุนต่อยอดการแยกขยะอื่นๆ เช่น การจัดหาถังแยกขยะมาตรฐาน การปรับปรุงสิ่งแวดล้อมในบริเวณให้สะอาดและน่าดู เพื่อการพัฒนาที่ยั่งยืนต่อไป

ข้อเสนอแนะที่ 5 การจัดตั้งสถานีแยกและรวบรวมขยะ

เทศบาลควรพิจารณาจัดตั้งสถานีแยกและรวบรวมขยะในพื้นที่เพื่อเพิ่มประสิทธิภาพของกระบวนการการจัดการขยะในปัจจุบัน สถานีแยกฯ เป็นจุดแยกขยะเพิ่มเติมและรวบรวมขยะเพื่อนำกลับมาใช้ใหม่หรือขายต่อออกจากขยะรวมก่อนนำไปกำจัดที่โรงงานไฟฟ้าพลังงานขยะ (WTE) สถานีแยกฯ ควรมีจุดเก็บของเสียอันตรายเพื่อการบำบัดอย่างถูกต้อง คณะผู้วิจัยขอเสนอให้ ทต. ใช้สถานีแยกฯ ช่วยบรรเทาปัญหาขยะในพื้นที่ อบต.ด้วย ตำแหน่งของสถานีแยกฯ ควรอยู่กึ่งกลางเส้นทางเก็บขยะเพื่อช่วยลดระยะทางในการขนส่ง บุคคลากรของสถานีแยกฯ จะต้องได้รับการอบรมอย่างถูกต้องเพื่อการบริหารจัดการขยะชุมชนอย่างปลอดภัย

ข้อเสนอแนะที่ 6 ปรับเส้นทางการเก็บขยะและจัดหาสถานที่กำจัดขยะที่เหมาะสม

ในปัจจุบัน อบต.ไม่มีสถานที่กำจัดขยะในพื้นที่ จึงจำเป็นที่จะต้องเร่งหาหน่วยงานร่วมเพื่อ ใช้สถานที่กำจัดขยะร่วมกัน นอกจากการเร่งหาสถานที่กำจัดขยะแล้ว อบต. ควรปรับเส้นทางเก็บขยะให้เหมาะสม โดยพิจารณาปัจจัยต่างๆ เช่น ระยะทาง ชนิดของขยะ ควรมีแผนการบริหารจัดการขยะทางการเกษตรเพื่อลดการเผาไหม้ในที่โล่ง ในกรณีของ ทต. ขยะจะถูกส่งไปกำจัดที่โรงงานไฟฟ้าพลังงานขยะนอกพื้นที่จึงควรปรับปรุงเส้นทางการเก็บขยะและตารางเวลาให้เหมาะสมกับความต้องการของประชาชน ความต้องการอาจเปลี่ยนแปลงได้ตามสถานการณ์ เจ้าหน้าที่ควรตรวจสอบและประเมินอย่างสม่ำเสมอเพื่อให้การบริการมีประสิทธิภาพสูงสุด การปรับปรุงวิธีการและขั้นตอนของกระบวนการจัดการขยะให้ทันต่อสถานการณ์และความต้องการของประชาชนอยู่เสมอจะสามารถโน้มน้าวประชาชนให้สนใจสิ่งแวดล้อมและสุขอนามัยเพิ่มขึ้น อันเป็นแนวทางที่ จะลดพฤติกรรมการกำจัดขยะผิดๆ เช่น การเผาในที่โล่งลงได้

Authorship

Report Sections	Author(s)	Editor(s)
Abstract	Zehra	Pimnapat, Zehra
Acknowledgment	Zehra	Pimnapat
Executive Summary	Zehra	Pimnapat
Executive Summary Thai	Kittipit, Phanpanadda	Kittipit
Glossary	Phanpanadda, Pimnapat, Zehra	Zehra
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2.2.1. Waste Management in Thailand According to the Laws	Phanpanadda	Zehra
2.2.2. Conceptual Framework of Waste Management	Phanpanadda	Zehra
2.2.3. Key Component of MSW Systems	Zehra	Pimnapat
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Finding 3: Thematic analysis led to an overview of barriers to effective municipal waste management in the Khuean Ubolratana Subdistrict	Phanpanadda	Adithep
Finding 4: Waste situations recurring in Khuen Ubolratana Subdistrict were identified, indicating where the recommendations should be provided	Phanpanadda	Adithep
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Glossary

Words Used	Meaning
MUNI	Subdistrict Municipality
SAO	Subdistrict Administrative Organization
Areas	
M1	Ban Phra Bat Village
M2	Ubolrataphittayakhom School
M3	Ubolratana Dam
M4	Khuean Ubolratana Subdistrict Municipality Fresh Market
M5	Ubolratana Hospital
S1	Ban Nonjik Village
S2	Phu Kam Bao School
S3	Bang Saen Song
Waste	
MSW	“Municipal Solid Waste” is another proper word for trash/garbage
Waste segregation	Action to separate different types of waste so that it can be recycled or disposed of effectively.
Collection service	Garbage truck service from the local administrative organization
WTE Plant	Waste management facility that combusts wastes to produce electricity
Waste processing	The treatment of solid waste after collection and before disposal
Others	
Commuter Population	Population of people who are present in an area during the day (ประชากรแฝงกลางวัน)
Non-registered population	The population who usually reside in one province but do not register in that province (ประชากรแฝงกลางคืน)

Chapter 1

Introduction

Waste, defined as unwanted and unusable products or substances no longer suited for their intended use, is an inevitable byproduct of human activities (University of Tartu, n.d.). Waste requires a considerable amount of time to decompose. Thus, waste management systems play a crucial role and are often implemented by governing bodies to effectively manage the waste generated, thereby aiding in minimizing the environmental impact of human activities (Prysmian Group, n.d.).

The exponential growth in global urbanization and population levels has led to a rapid increase in the volume of waste generated, surpassing the rate of urbanization itself (Chen, 2018). This phenomenon presents a formidable challenge in ensuring efficient waste management practices on a global scale. Annually, the amount of MSW generated globally is about 11.2 billion tons, a figure expected to increase by 70% by the year 2050 (Bruna, 2023). Given the alarming rise in waste generated, it becomes imperative to implement a well-structured waste management system. Such a system must be tailored to the needs of the target population to ensure its effectiveness. Improper waste management systems pose many disadvantages that can significantly impact the environment, public health, and overall well-being of communities.

Finding solutions to proper waste management still poses a challenge globally, specifically in developing countries, where issues such as limited financial resources and insufficient general awareness hinder the implementation of a proper waste management system. For instance, in Thailand, as of 2022, the number of complaints filed regarding environmental pollution has amounted to over 14.8 thousand cases. Despite the substantial volume of solid waste, estimated at over 25 million metric tons, Thailand relies on traditional informal waste management and recycling systems, predominantly utilizing landfills. Presently, there are less than 400 proper waste disposal sites, while 200,000 units of improper waste disposal sites are throughout the country (Statistia, 2023).

Open dumping of waste poses significant health risks due to the proliferation of disease vectors like rats, leading to food poisoning and diseases such as dengue and malaria (Somani, 2023). Additionally, it contributes to environmental pollution, soil degradation, and fire hazards (Yogalakshmi, n.d.). In Khon Kaen Province, Thailand, landfill sites across 26 districts are overwhelmed, holding approximately 800,000 tonnes of rubbish, making it the largest garbage dump in the Northeast region (Jakkrapan, 2014). Consequently, residents of Khuean Ubolratana Subdistrict resort to informal waste management methods like burning or improper dumping. Acknowledging the urgency of this issue, the former head of the Ubolratana Hospital Foundation, our sponsor, aims to enhance the waste management system in the subdistrict.

Waste management practices vary significantly across countries and regions, depending on socioeconomic, cultural, political, and environmental. In order to enhance the waste management system in Khuean Ubolratana Subdistrict, it is essential to conduct a comprehensive review of efficient waste management systems through observations and case studies to provide valuable insights into the key factors that need to be assessed and addressed in Khuean Ubolratana Subdistrict.

The primary purpose of this project was to investigate the Local Administrative Organization's waste management system and identify the cause of the problems. The aim was to provide recommendations for the Khuean Ubolratana Subdistrict area. Our team identified some achievable objectives to achieve this goal.

(1) Understand the local administrative organizations' waste management systems.

(2) Compare the current systems to the benchmark and identify the discrepancies and causes of the problem.

(3) Provide practical recommendations to improve the waste management system for Khuean Ubolratana Subdistrict.

To achieve the objectives, the team undertook a multifaceted approach. Firstly, the team interviewed the MUNI and SAO to understand existing waste management systems, analyzing the gathered information to create flowcharts depicting MSW processes. These visual aids enabled us to identify any deviations in waste management procedures. Secondly, the team interviewed community members and conducted fieldwork in eight selected areas within the subdistrict to gain insight into current waste management practices. The team employed various analyses, including MSW Process Analysis flowcharts, Map Analysis, and Thematic Coding Analysis, to assess the effectiveness of waste management efforts and identify areas for improvement. Additionally, the team visited organizations renowned for their successful waste management initiatives, such as Roong Aroon School, the Pollution Control Department (PCD), and Chula Zero Waste. Here, the team gathered practical ideas for recommendations and insights applicable to Khuean Ubolratana Subdistrict. The information gathered for recommendation will lead to the final objective: to design recommendations for alleviating the waste management problem recurring in the Khuean Ubolratana Subdistrict. By achieving these objectives, our team will be able to thoroughly understand the current waste management systems in Khuean Ubolratana Subdistrict. Thus, the team will be able to develop recommendations suitable for alleviating the recurring waste management system problem. This could reduce the negative social and environmental impacts, such as decreased waste burning and improper waste dumping in Khuean Ubolratana Subdistrict. We firmly believe that by implementing these recommendations and drawing insights from successful initiatives, the community can progress towards a more sustainable and environmentally aware future.

Chapter 2

Literature Review

2.1. Concept of Waste

2.1.1. Types of Wastes

A classification system of 4(+1) types in Thailand is established to facilitate effective waste management, encompassing organic, hazardous, recycled, and general waste. Additionally, a specific category for infectious organic waste is implemented when such waste is present. This ensures that local government organizations can efficiently handle each type of MSW, streamlining operations and minimizing the risk of disease transmission and potential hazards associated with waste collection activities (Pollution Control Department, 2020).

Waste Category	Definition	Example
(1) Organic Waste (Food waste)	Waste that is decomposable and decays quickly.	Fruit peels, fruit scraps, food leftovers, leaves, and animal scraps
(2) Hazardous Waste from Communities	Waste that is contaminated or contains the following components: explosives, flammable materials, radioactive substances, and hazardous substances that cause diseases	Batteries, fluorescent bulbs, mobile phones, containers used to hold insecticides or herbicides, and spray cans containing paint or chemicals
(3) Recycle Waste	Discarded packaging or reusable materials that can be recycled for new purposes	Glass, paper, cans, beverage containers, plastic scraps, metal scraps, aluminum, car tires, and milk cartons
(4) General Waste	Other types of waste apart from the above are characterized by being slow to decompose and not cost-effective for recycling or repurposing	Plastic bags, food-contaminated foam, food-contaminated foil, and packaging for various consumer goods

(5) +1 Infectious Waste from communities	Waste contaminated with materials that can cause bloodborne diseases and secretions from patients receiving home-based care or returning home after medical treatment.	Cotton pads, gauze, wound dressing, disposable diapers, absorbent sheets, face masks, rubber gloves, urinary catheter bags, and needles or insulin syringes

Table 1. Types of Waste

2.2. Waste Management in Thailand

2.2.1 Waste Management in Thailand According to the Laws

According to the Factory Act 1992, under the authority of the Minister of Industry, industrial hazardous waste shall be managed per the act's requirements. For the remainder, as stated by the Public Health Act of 2017, **the local government organizations must collect, transport, and dispose of sewage or waste within their responsible area**. They may do so in conjunction with other government agencies or local governments under a joint agreement or assign a person to do so. Plus, they shall have the power to prescribe rates of fees for services provided by the local government or other person assigned to operate on its behalf in the collecting, transporting, or disposing of sewage or waste that do not exceed the rates prescribed in the Ministerial Regulation. Moreover, it was also stated in the Determining Plan and Process of Decentralization to Local Government Organization Act, 1999, that the local government organization shall have the authority to systematize public services, such as managing waste, sewage, and wastewater, for the benefit of local communities.

2.2.2. Conceptual Framework of Waste Management

The Pollution Control Department released the 2nd National Action Plan on Waste Management (2022-2027). It serves as guidelines for any associated organizations, including Local Administrative Organizations. In this plan, they restructured the waste management Hierarchy, emphasizing waste prevention, followed by waste minimization, recycling, recovery, and disposal, respectively, as illustrated in Figure 2.

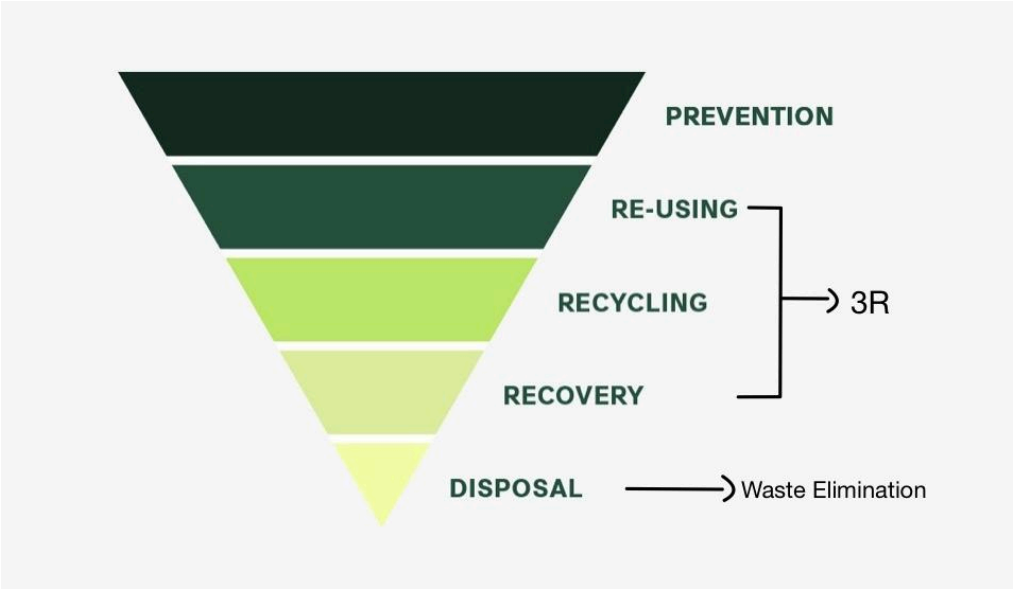

Figure 2. Waste Management Hierarchy

The plan details measures for efficient waste management based on the Life Cycle Management Approach. It addresses waste throughout the entire lifecycle of goods based on the 3R referred to in Figure 2. As shown in Figure 3, there are three steps in managing waste.

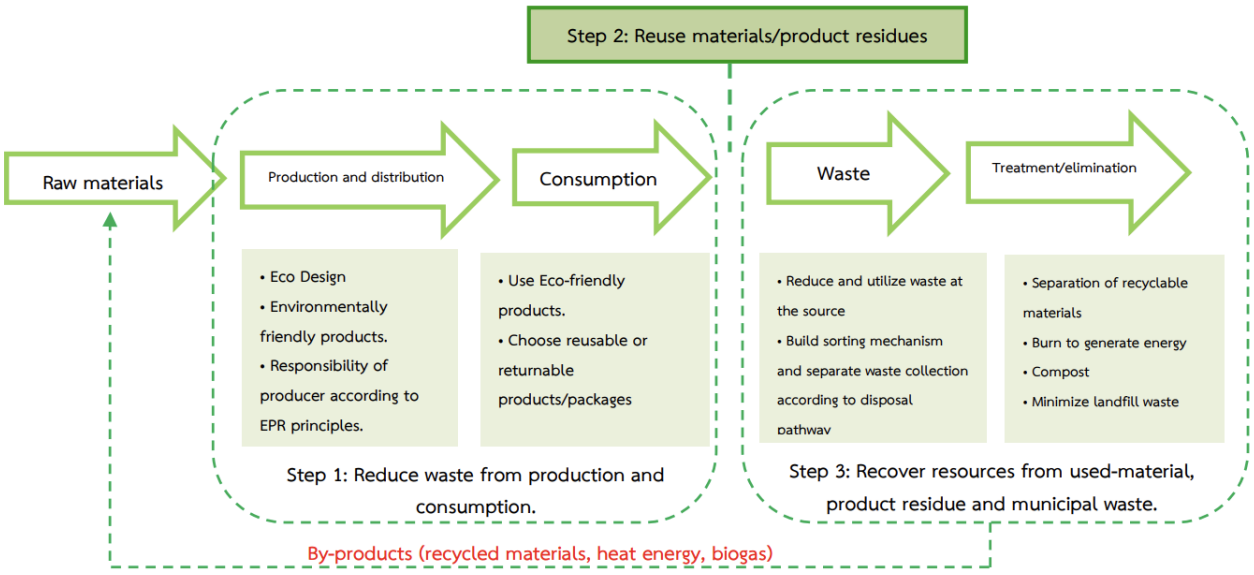

Figure 3. Life Cycle Management Approach

The measures for efficient waste management are outlined below:

(1) Upstream management: The process involves designing products with environmental considerations, manufacturing, and distributing environmentally friendly products. It entails delineating the responsibilities of various stakeholders, including producers, importers, and distributors, to collectively share the responsibility for the entire lifecycle of their products.

(2) Midstream management: Promoting sustainable consumption, encouraging eco-friendly product use, and minimizing environmental impact. It involves selecting reusable products, facilitating recycling, reducing environmentally burdensome packaging, and implementing waste separation for resource recovery. The aim is to minimize the final disposal of waste.

(3) Downstream management: Integrated solid waste management uses multiple technologies to reduce waste disposal via sanitary landfills, such as material separation and recovery systems incineration to produce energy and fertilizer.

(4) Developing efficient waste management tools: This encompasses creating laws that specify guidelines for the management and roles of individuals involved in waste management.

2.2.3. Key Component of MSW Systems

For effective MSW management, one must consider the interconnections of five critical steps before deciding on a final disposal strategy, ensuring a comprehensive and efficient approach to waste management (Saleh & Koller, 2019).

The efficient MSW process should include five of the waste life cycle:

(1) Source: Waste, created at its origin without added value, is discarded. The amount and characteristics of various waste types vary based on the specific waste source, influencing waste management decisions.

(2) On-site Management: The subsequent phase involves directly managing waste at its origin, incorporating tasks such as handling, separation, and on-site storage. This step is crucial for efficient waste management practices, ensuring proper sorting and storage before further disposal actions.

(3) Waste Collection: At the facility, garbage trucks gather waste from various bins, including garbage, recycling, and skip bins. Afterward, the collection team manually sorts the waste before transporting and disposing of it at designated waste transfer facilities.

(4) Waste Transfer: Following waste collection, garbage trucks transport it to a crucial step, the waste transfer station. This phase is pivotal as contemporary waste and recycling equipment can efficiently sort and handle the waste. Waste transfer stations play a vital role in sorting and consolidating waste from diverse sources before transporting it to appropriate disposal sites.

(5) Waste Disposal: The ultimate phase involves waste processing and final disposal. This step ensures proper treatment and responsible disposal methods are applied to manage waste effectively and sustainably.

2.2.4. Importance of Waste Management

Implementing an effective waste management system helps increase the lifecycle of products, promoting reuse and material recovery. This ultimately reduces the total amount of waste that goes into landfills and minimizes the environmental burden. Thus, waste management is pivotal in sustainable development, positively impacting a country or community's environment, social dynamics, and economic progress. For instance, after recyclable wastes are reprocessed or transformed into new products, it can help conserve natural resources, reduce energy consumption, and alleviate the strain on landfills by diverting recyclable materials away from disposal sites (Stewart, 2010).

2.3. Waste Situation

2.3.1. Waste Situation in Thailand

In 2020, Thailand generated approximately 28.71 million tons of MSW. This increase in waste generation is attributed to the expansion of urban communities, the rise in tourism promoting travel, and the influx of foreign labor contributing to the overall population. Analyzing the overall 2019 management of MSW, it was observed that 12.52 million tons were effectively utilized. This amount increased compared to the previous year. Moreover, 9.85 million tons were appropriately disposed of. There was a decreasing trend in this figure compared to the previous year. This overall improvement in waste management can be attributed to the efficient operation of several cluster-based waste disposal facilities. However, some of these facilities needed to be adequately managed, impacting the effectiveness of waste disposal. Consequently, several community waste disposal sites operated improperly, leading to around 6.34 million tons of inappropriate disposal (Pollution Control Department, 2021).

The 2020 waste management landscape comprised 2,666 community sites and 25 transfer stations. Within this framework, 409 sites adhered to proper waste management practices, embracing methods such as landfilling, semi-aerobic landfilling, energy-producing incineration, incineration with air pollution control, composting, and refuse-derived fuel (RDF) production. However, the stark reality revealed a substantial number of sites, precisely 2,257, operating improperly, resorting to open dumping, open burning, and incineration without adequate pollution control measures (Pollution Control Department, 2021).

The absence of waste transfer stations in numerous provinces across Thailand is noteworthy. Waste transfer stations play a crucial role in the waste management infrastructure. They serve as intermediate points for collecting, sorting, and temporarily storing waste before transporting it to final disposal sites or recycling facilities. The lack of such facilities in many provinces can pose challenges in optimizing waste management processes, leading to potential issues in waste handling, sorting efficiency, and overall environmental impact.

The urgency of implementing comprehensive waste management strategies became abundantly clear, necessitating a concerted focus on addressing capacity limitations, operational deficiencies, and the burgeoning impact of online consumption patterns. A prominently concerning trend in 2020 was the escalating quantity of packaging waste, particularly single-use plastics. This surge was intricately linked to the burgeoning popularity of online shopping and the pervasive reliance on food delivery services. The implications of this trend underscored the importance of adapting waste management strategies to align with evolving consumer behavior, emphasizing the significance of sustainable practices in the face of changing consumption patterns. Tackling these issues head-on would be paramount to fostering sustainable waste management practices and mitigating the adverse environmental consequences of community waste mismanagement (Pollution Control Department, 2021).

2.3.2. Waste Situation in Khon Kaen

The waste problem in Khon Kaen is directly related to growing urbanization and shifting consumer habits. As of 2021, the administrative area was 10,885.99 square kilometers, with 1 city municipality, 6 town municipalities, 77 sub-district municipalities, and 140 sub-district administrative units. It is critical to ensure appropriate trash disposal, and the region has eight authorized facilities capable of managing solid waste. Challenges remain, with 263 places recognized as areas where garbage disposal is insufficient, underscoring the importance of comprehensive waste management practices in developing a cleaner and more sustainable environment. Furthermore, the daily waste production is approximately 718.78 tons, which highlights the waste situation. Nevertheless, a significant amount of this trash comes from regions that do not practice adequate waste management, and instead, they depend on open dumping. This widespread problem emphasizes the importance of comprehensive garbage disposal systems. However, there is a positive aspect to the waste situation: a significant amount of successful waste management, roughly 400 tons per day, occurs at the power plant generating electricity from garbage in Khon Kaen (Pollution Control Department, 2021).

Khon Kaen needs help with the complex interplay of urbanization, shifting lifestyles, and evolving consumption patterns, leading to a substantial increase in waste generation. The surge in urbanization, driven by factors like job opportunities, has particularly heightened domestic waste output. Beyond environmental concerns, the waste issue in Khon Kaen has adverse effects on green spaces. A significant dispute between Tambon Ban Pet and the Khon Kaen municipality revolved around wastewater from Khon Kaen Airport affecting Nong Kot Pond. This dispute intensified during the 2011 floods when Tambon Ban Pet accused the municipality of exacerbating the flooding by closing water gates. In response, the municipality implemented measures like restricting waste disposal hours, but the limited resources and trash pickup vehicles resulted in delays and community discomfort. The waste management challenge in Khon Kaen underscores the broader implications of urban expansion on ecological issues and the need for effective solutions (Thongyou et al., 2014).

Khon Kaen is confronted with significant administrative challenges due to urbanization, leading to inefficiencies in waste management. The local administration's structure, divided into smaller zones like city and subdistrict municipalities, needs to address the effects of growing urbanization, which results in system breakdowns. For instance, the city needs a proper waste disposal infrastructure, leading to untreated solid waste being deposited in rural areas. This failure exposes the population to severe risks, necessitating immediate attention and coordinated efforts for a sustainable future. Collaboration among stakeholders is crucial for a cleaner, healthier, and more sustainable city. Through comprehensive strategies and collective dedication, Khon Kaen can transform its waste management practices and build a more resilient urban environment (UCRSEA, n.d.).

2.4. Case Study of Waste Management

2.4.1 Mai Tay Ruam Campaign of the Bangkok Metropolitan Administration

The Mai Tay Ruam (ไม่เทรวม) campaign of the Bangkok Metropolitan Administration (BMA) exemplifies a proactive approach to promoting the segregation of food waste from general waste, aligning seamlessly with the waste separation policy instituted by the Governor of Bangkok. This policy is strategically designed to serve as a blueprint for waste separation at the district level, emphasizing a holistic approach to waste management. The overarching goal is to effectively tackle waste-associated challenges by implementing streamlined waste separation practices, thereby addressing issues upstream in the waste management process.

A pivotal component of this campaign is the BMA's introduction of state-of-the-art garbage trucks. These innovative vehicles are equipped with specialized storage compartments dedicated to food waste. They come in two variants: rear-compacting and side-opening, facilitating the separate collection of food waste from other waste categories. This deliberate separation addresses concerns such as leachate and odors during collection and disposal, and positions collected food waste for efficient utilization, thus augmenting the overall value of the waste management process. The initial deployment of these advanced vehicles is concentrated in the pilot areas of three districts: Pathum Wan, Phaya Thai, and Nong Khaem.

The Mai Tay Ruam (ไม่เทรวม) campaign unfolds systematically across three phases—monitoring, assessment, and improvement. The first phase, initiated between September and October 2022, was implemented along a specified route in one district. Subsequently, the second phase, spanning November to December 2022, expanded to cover all routes at the sub-district level. The third phase, scheduled for January to March 2023, marked an extensive expansion encompassing the entire pilot area across the three districts.

The waste collection system, tailored for different types, involves using open-sided garbage trucks with a 1.5-ton capacity. These trucks are dedicated to collecting food waste in each district during specified hours, setting this process apart from regular waste collection schedules. Moreover, compact garbage trucks with a 5-ton capacity undergo modifications to include an additional bin at the rear for food waste, complemented by BMA's two bins in the front section.

Furthermore, the collected food waste undergoes a sophisticated treatment process at the On Nut treatment facility, leveraging Mechanical and Biological Waste Treatment (MBT) technology. This innovative method entails waste fermentation to generate biogas for electricity production. The program is poised for substantial expansion in 2023, extending its coverage to 47 districts with three pilot routes and sub-district levels (Team, 2022).

2.4.2. Waste Management in Singapore

Singapore has experienced rapid industrialization and urbanization over the past four decades. This development has led to a significant increase in solid waste generation, with annual disposed solid waste rising from 0.74 million tonnes in 1972 to 2.80 million tonnes in 2000. Initially relying on landfill-centric waste disposal practices during the 1960s and 1970s, the country faced challenges such as limited landfill space, environmental concerns, and the putrefied nature of waste in its warm and humid climate. Consequently, Singapore gradually shifted away from landfill-centric practices, adopting a more comprehensive waste management system in the 21st century (Richards et al., 2020).

Singapore implemented a sustainable and integrated waste management system. This system emphasizes the waste hierarchy of waste minimization (3Rs), incineration, and landfill, with a preference for waste-to-energy (WTE) incineration programs. The National Environmental Agency (NEA) launched various initiatives, including the "Zero Waste Master Plan" in 2019, aimed at reducing landfill-bound waste by 30% (Zhou et al., 2022). The "National Recycling Program" was introduced in April 2021, requiring public waste collectors to provide recycling bins and services, promoting a commingled collection system to enhance recycling efficiency.

The waste-to-energy incineration process in Singapore saves valuable landfill space, where approximately 90% of solid waste is reduced through incineration. The heat energy produced during incineration is harnessed to generate 3% of the island's electricity, while the gasses emitted during incineration are filtered before release. Incineration ash and non-incinerable wastes are transported to Tuas Marine Transfer Station and eventually disposed of at Semakau Landfill, which involves depositing ashes into a confined water body, ensuring environmentally responsible waste management practices (Richards et al., 2020).

Chapter 3

Methodology

This project investigated waste management procedures and issues within the MUNI and the SAO in Khuean Ubolratana Subdistrict, Khon Kaen Province, and their impact on community well-being. A literature review was conducted to obtain fundamental information on the current waste management system in the Khuean Ubolratana Subdistrict. The team recognized the significance of waste management problems in the Khuean Ubolratana Subdistrict community, prompting further investigation. With the support of our sponsor, the Ubolratana Hospital Foundation team aimed to gain a better understanding and adopt a critical approach to addressing waste management issues in the Khuean Ubolratana Subdistrict. This chapter describes the objectives and methodology in detail. The project's objectives included:

(1) Understand the waste management system of the Local Administrative Organizations.

(2) Compare the current system with the protocol and identify the root causes of the problems.

(3) Provide practical recommendations to improve the waste management system for Khuean Ubolratana Subdistrict.

3.1. Understand the waste management system of the Local Administrative Organizations

This segment was conducted during the fieldwork at the Khuean Ubolratana Subdistrict. The team interviewed two government organizations, the MUNI and the SAO, to develop a thorough understanding of the subdistrict's waste management system.

3.1.1. Interviewed the MUNI and the SAO officers responsible for the waste management of the Khuean Ubolratana Subdistrict community

Conducting interviews with the responsible officials is crucial to comprehend the existing waste management system. These interviews offered valuable insights into the current waste management policies proposed by the officials for their respective communities. A predefined set of questions was employed during the interviews, focusing on waste management's collection, transportation, and disposal processes. These aspects were emphasized due to their fundamental nature and role in gathering key information about waste management practices. The list of questions facilitated the acquisition of information necessary for identifying problems and understanding the waste management scenarios in the areas. Additionally, the interviews provided insights into each responsible organization's needs, challenges, and plans for waste management.

Moreover, participant records were maintained with their consent to ensure the accuracy of the information collected. The consent letter can be viewed in Appendix C, and the complete list of questions used for the interviews is available in Appendix B.

3.1.2. MSW process analysis of the waste management protocol

After the interviews with the MUNI and the SAO, an analysis of the MSW process based on the protocols proposed by the officials was conducted. Flowcharts were utilized to visually represent the waste management plans of each government organization, incorporating the five essential steps of MSW management: source, on-site waste management, waste collection, waste transfer, and waste disposal. These protocol flowcharts allow the team to identify the potential problems and areas that need improvement. The flowchart for the MUNI is blue, while the SAO's is pink; see detailed flowcharts in Appendix D.

3.2. Compare the current system with the protocol and identifying the root causes of the problems

This section encompassed the fieldwork, involving interviews with community members and direct observations within the Khuean Ubolratana Subdistrict areas. Subsequently, an analysis was conducted after the fieldwork to utilize the information gathered to identify the problems occurring within these areas.

3.2.1. Interviewed the community members within the MUNI and the SAO responsibility for waste management

Interviews were conducted with local community members to gather insights directly from the local perspective on community waste management. The interviews targeted participants from five main areas, each presenting a different waste profile and situation.

The team collected information from residents about how waste management policies proposed by officials impact them and the actual waste problems occurring within their areas. This information provided insights into the effectiveness of waste management by the two officials and allowed the team to comprehend the waste situations the locals face and assess how the officials' waste management policies influence quality of life. Additionally, the team gathered information on the locals' satisfaction and needs regarding the waste management system. Table 3 outlines the specific areas and types of local participants chosen for the interview.

Name of the Area	Type of Participant
(1) M1: MUNI Residential Area: *Ban Phra Bat Village* **(2)** S1: SAO Residential area: *Ban Non Jik Village*	**(1)** Residents **(2)** Subdistrict Headman **(3)** Village Headman
(1) M2: MUNI School Area: *Ubolrataphittayakhom School* **(2)** S2: SAO School area: *Phukambao School*	**(1)** Teachers **(2)** Students
(1) M3: MUNI Tourist Area: *Ubolratana Dam* **(2)** S3: SAO Tourist area: *Bang Saen Song*	**(1)** Tourists **(2)** Residents **(3)** Subdistrict officials
(1) M4: MUNI Market Area: *Khuean Ubolratana Subdistrict Municipality Fresh Market*	**(1)** Sellers **(2)** Residents
(1) M5: MUNI Hospital Area: *Ubolratana Hospital*	**(1)** Public Health Technical Officer, Professional Level

Table 2. List of Local Participants for the Interview

The interviews aimed to uncover diverse waste management policies and behaviors across different sectors within the district. Schools, including Ubolrataphittayakhom and Phukambao, were surveyed for the educational efforts. The Khuean Ubolratana Subdistrict Municipality Fresh Market and tourist areas like Ubolratana Dam and Bang Saen Song were chosen to understand waste generation at high-density sites. Residential areas, Ban Phra Bat Village and Ban Non Jik Village, were chosen for community perspectives. Ubolratana Hospital, though under municipal jurisdiction, handles waste independently. Participant records were made with consent to ensure information accuracy. The consent letter and the interview questions are in Appendix B and C.

3.2.2. Direct observation of the current waste management system within the areas

To verify the information provided by officials, conducting fieldwork and observing the areas under the jurisdiction of both the MUNI and the SAO in Khuean Ubolratana Subdistrict is crucial. The team conducted on-site observations during interviews with local community members, focusing on garbage bin types, their locations, the amount of waste in the vicinity, and the presence of incineration areas. These observations aimed to comprehend the diverse waste management practices across different areas and assess their alignment with the information gathered from interviews. Employing a non-participant observation method, the team recorded notes and took pictures for subsequent analysis.

3.2.3. MSW process analysis for the waste management system in each specific area

The MSW practices in the 8 observed sites were analyzed and presented as flowcharts, illustrating the waste management practices in each area and assessing how community members handled and sorted their waste. These area-specific flowcharts can be compared with protocol-type flowcharts to determine whether community members follow the waste management plans recommended by officials. Appendix D shows the flowcharts for the eight specific areas within Khuean Ubolratana Subdistrict.

3.2.4. Data analysis

After the data collection, two types of analyses were conducted: Map Analysis and Thematic Coding Analysis. Both methods are essential in proposing potential recommendations for identifying problems and areas for improvement in the Khuean Ubolratana Subdistrict.

Map Analysis presents an overall view of the Khuean Ubolratana Subdistrict, emphasizing the differences between the MUNI and SAO areas. The map also indicates locations visited during the fieldwork for local community interviews and direct observations, along with the number of interviewees. The MUNI's visited areas are marked in light blue shapes, while the SAO's are in pink. The different shapes are used as keys to identify each specific area the team visited during the fieldwork. Another analysis the team used was thematic coding analysis, which was done by reviewing the information gained from the interviews with 31 community members within eight sites during the fieldwork. This information was then used to highlight and group the waste problem keywords into themes. The team did this analysis using Google Sheets and created bar graphs, pie charts, and graphic illustrations to compare the keywords mentioned by the community members from the two authority areas. The highest amount of keywords mentioned would identify the waste problems occurring within the areas. The thematic analysis results illustrated in bar graphs for both MUNI and SAO can be seen in Appendix E.

3.3. Provide practical recommendations to improve the waste management system for Khuean Ubolratana Subdistrict

This section provides potential and fitting recommendations for a waste management system in Khuean Ubolratana Subdistrict for the sponsor and communities. These recommendations are derived from the insights gained through interviews with waste-related organizations.

3.3.1. Interviewed waste-related organizations to collect waste management knowledge and policy

Following the analysis of data gathered during the initial fieldwork in Ubolratana Subdistrict, Khon Kaen, it became evident that conducting additional interviews with established waste-related organizations would enhance our understanding and insights into waste management. The listed organizations are as follows:

(1) Pollution Control Department (PCD)

(2) Roong Aroon School

(3) Chula Zero Waste

The Pollution Control Department (PCD) actively addresses environmental issues, aligning with national legislation. The knowledge from this organization allowed the team to visualize the scale and the components needed to be prioritized in improving waste management within the areas. Roong Aroon School demonstrates exemplary zero waste management practices, offering a detailed and easily adoptable waste sorting system. During the visit and discussion, the team explored the best practice protocols, contributions, and high cooperation among the people within the school. Chula Zero Waste, a program at Chulalongkorn University, collaborates with various entities to minimize waste and preserve the campus environment.

The team compiled data on waste sorting processes and policies from these organizations, seeking insights into their waste management strategies and challenges. Using this knowledge, the team analyzed and related it to waste management in Khuean Ubolratana Subdistrict, integrating fieldwork data for comprehensive insights and analysis. The organization gained plenty of interesting programs contributing to sustainable waste management as ideas for the Khuean Ubolratana Subdistrict.

3.3.2. SWOT analysis

The team created a SWOT analysis after gathering all the information from fieldwork. It was created into mainly 2 authorities, the MUNI and the SAO, including some specific areas within each authority's areas. This evaluation evaluated the two government organizations' strengths, weaknesses, opportunities, and threats. Each character from the areas within each authority were addressed in detail to understand better the requirements and the absence in enhancing effective waste management. Therefore, this analysis helped the team to construct recommendations to improve waste management systems that best fit the community.

3.3.3. Proposed possible recommendations to alleviate the waste-related problem

The team identified the most suitable recommendations for Khuean Ubolratana Subdistrict communities. The SWOT analysis of the areas within MUNI and SAO, containing four characteristics, strengths, weaknesses, opportunities, and threats, were used to identify the problems that need improvement and provide suitable recommendations. Besides, the data analysis, including MSW process analysis flowcharts, map analysis, and thematic coding analysis, were parts of conducting potential recommendations for the areas. The recommendations were categorized according to the key components from MSW waste management process analysis as follows;

(1) Source

(2) On-site waste management

(3) Waste Transfer Station

(4) Waste Disposal

Chapter 4

Results and Analysis

This project aimed to provide practical solutions to the problems in Khuean Ubolratana Subdistrict through data analysis. The research objectives were as follows: learn about the current local waste management system in Khuean Ubolratana Subdistrict, compare the current system to the benchmark, identify the problem and discrepancy, and provide potential solutions to improve the current waste management process in Khuean Ubolratana Subdistrict. The team interviewed the authorities and the residents at eight sites to assess and understand waste management in the Khuean Ubolratana Subdistrict. We conducted direct observations of the waste systems implemented in the area. Findings were categorized into two areas overseen by two different authorities: the MUNI and the SAO.

4.1. Research Findings

In this section, we provide analysis results derived from collected data using various methods outlined in the methodology. We have identified five major findings, which will be detailed below.

Finding 1. Official waste management protocols are simplified as flowcharts to identify discrepancies and problems according to them

Finding 1.1. The MUNI protocol flowchart

Through interviews with the Mayor and his team and direct observations, the team acquired valuable insights into the current waste management systems designed for Khuean Ubolratana Subdistrict and administered by the MUNI. Figure 4 depicts the team's defined flowchart of the current waste management protocol for official implementation.

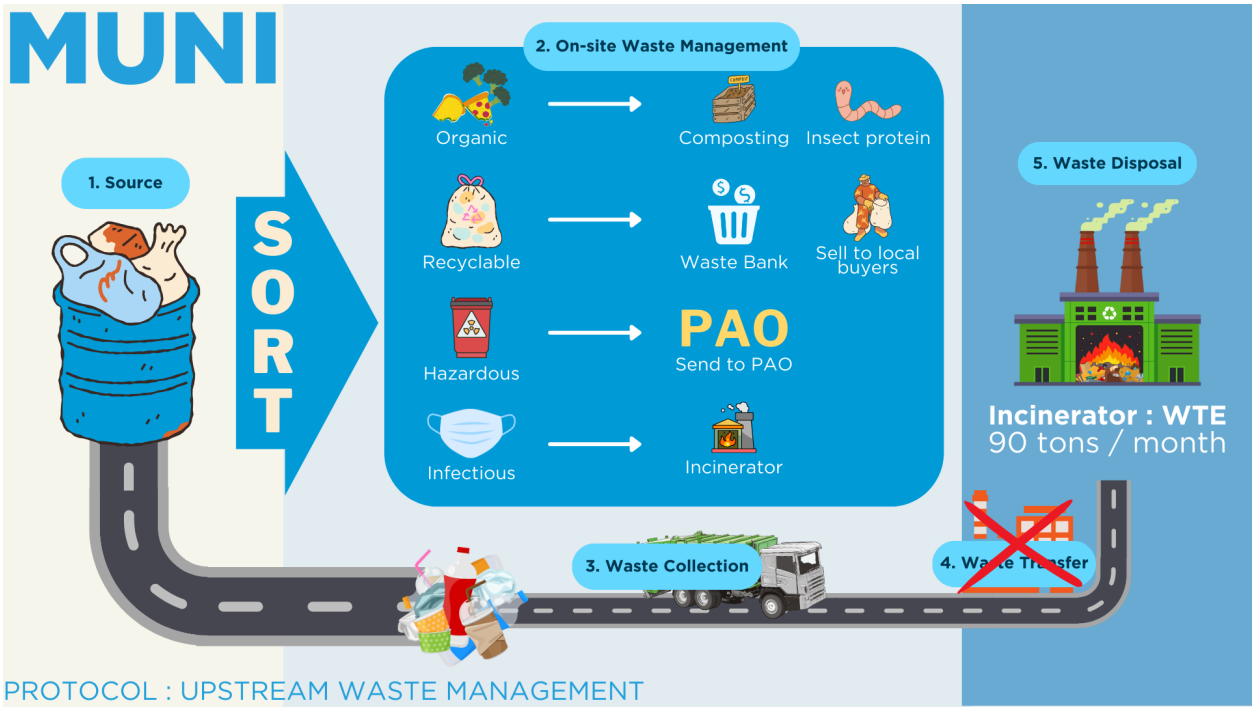

Figure 4. MUNI Protocol Flowchart

The MUNI Waste Management Protocol starts from the source, including all types of waste generated in the community. On-site waste management is prioritized, and each kind of waste should be sorted and utilized according to the 3R concept to minimize the amount of unsorted waste sent to the WTE plant located at Ban Kum Bon. Starting from the top, according to the figure, organic waste should be composted or fed to insects. MUNI recently started a campaign called "Waste Bank," in which they directly buy certain types of recyclable waste from the community, and some other recyclable waste can be sold to the recycling merchants. Hazardous waste is collected once a year by the PAO (Provincial Administrative Organization). The infectious waste is collected from each site and sent to the hospital for incineration.

Finally, the designated official collects the remaining waste. The diagram indicates a lack of a waste transfer station, which hampers further waste segregation after collection. The waste is transported to the Waste-to-energy (WTE) plant for energy production.

Finding 1.2. Potential problems according to the MUNI protocol flowchart

Although the 3R concept is expected to be implemented, not everyone can comply with the plan to minimize waste generation. The most important aspect of the 3R concept is promoting reusing waste. The Waste Bank system also relies heavily on community participation, which could only be effective with sufficient incentives for the locals to participate in the program regularly.

If hazardous waste is collected only once a year, it could pose risks in terms of storage and potential environmental or health hazards if not appropriately managed throughout the year. More frequent or accessible hazardous waste collection services may be needed.

The locals might sort the waste to some extent, but a waste transfer station is needed. Including a waste transfer station in an appropriate location in MUNI could drastically improve waste segregation. Any unsorted waste by the community would be processed at the station to ensure that all types of waste are sent to their designated places.

Finding 1.3. The SAO protocol flowchart

The SAO protocol flowchart shares patterns similar to those of MUNI. However, according to Figure 5, some key differences must be clarified.

Figure 5. SAO Protocol Flowchart

Unlike MUNI, the SAO lacks a proper waste disposal site, which means waste collection is absent in all areas under the SAO's jurisdiction except for Bang Saen Song, where waste is collected during special events. Waste transfer stations are also lacking in SAO, which is similar to MUNI. Lastly, the waste collected is subjected to open burning as there is no proper place to discard it.

Finding 1.4. Potential problems according to the SAO protocol flowchart

The main problem in SAO is the need for a waste disposal site to compensate for the lack of waste collection service. Improper waste disposal, such as landfills, can result in environmental pollution and degradation of soil, water bodies, and air, leading to adverse health effects for residents and wildlife. Accumulation of waste in open spaces or waterways can also attract pests and vermin, increasing the risk of disease transmission. Additionally, the lack of waste collection infrastructure can hinder economic development and tourism, as unsightly waste can keep visitors from enjoying the beautiful nature of Khuean Ubolratana Subdistrict. Over time, the persistence of these issues can erode community well-being, degrade the quality of life, and undermine efforts for sustainable development in the area.

Finding 2. Geographical insights of Khuean Ubolratana Subdistrict and the effects on waste management of the officials

The map analysis emphasizes the team's observation sites in the Khuean Ubolratana Subdistrict. The color coding and the map scale indicate the relative distances between each MUNI and SAO site. Light blue represents the MUNI sites, while pink represents the SAO sites, with different shapes denoting specific areas under the jurisdiction of the two officials. Through this visualization, the team gained a consolidated overview and geographical understanding of the proximity among the visited sites.

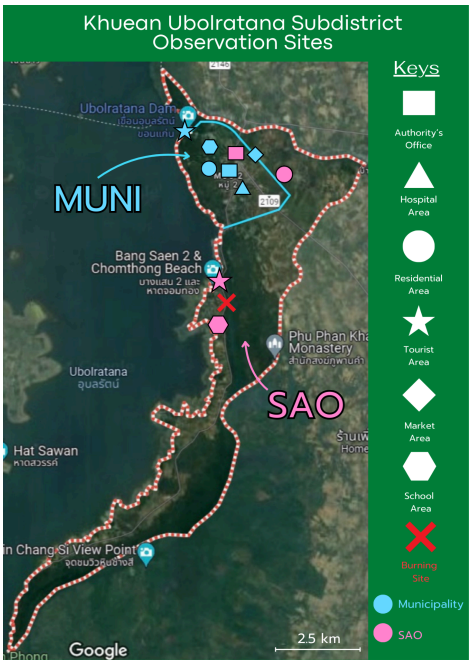

Figure 6. Map Analysis of Khuean Ubolratana Subdistrict

The Subdistrict areas can also be seen clearly in Figure 6, with 8.70 km² under the responsibility of the MUNI and 87.60 km² under the SAO. However, the difference in area sizes does not reflect the two regions' populations. MUNI has slightly more at 4,041, while SAO only sustains 3,353 people. Despite its smaller size, the MUNI is characterized as a semi-urban, semi-rural society community with a notably higher population density. In contrast, despite its expansive area, which is ten times more than the MUNI area, SAO maintains a population size similar to that of the MUNI and is recognized as a rural society community.

Due to having much less area than SAO, MUNI is much more condensed, with key places compacted together, as shown. This causes higher waste accumulation in certain spots of MUNI. The WTE (waste-to-energy) plant is also quite far from MUNI, as shown in Figure 7, which leads to inefficient waste transfer. On the other hand, SAO has a larger area with population spreading out with primary land usage as an agricultural area. Consequently, the types of waste in the two areas differ. The red cross on the SAO side (Figure 6) indicates the burning site neighboring Bang Saen Song used by the official.

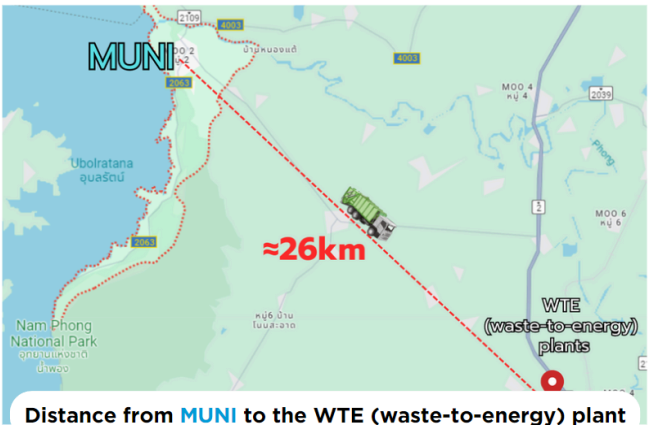

Figure 7. Distance from MUNI to WTE plant

The distance from MUNI to the Waste-to-Energy (WTE) plant is 26 kilometers, which is significant. Transporting waste directly to the disposal site over such a distance poses logistical challenges. Additionally, the absence of a designated location for waste accumulation before disposal exacerbates this issue.

Layouts of buildings and infrastructure also play a pivotal role in how waste might accumulate in an area. As shown in Figure 8, Ubolratana Dam's vicinity is well-planned and not crowded. This reflects on the area's waste generation and proper waste management conducted. Conversely, Bang Saen Song is densely populated with tightly packed structures, as illustrated in Figure 9 by the satellite view of Google Maps. Consequently, waste management is more challenging, and extra attention should be paid to these areas.

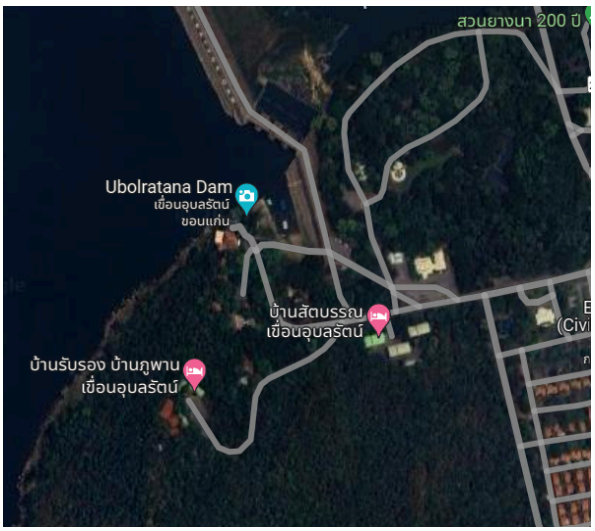

Figure 8. Satellite View of Ubolratana Dam

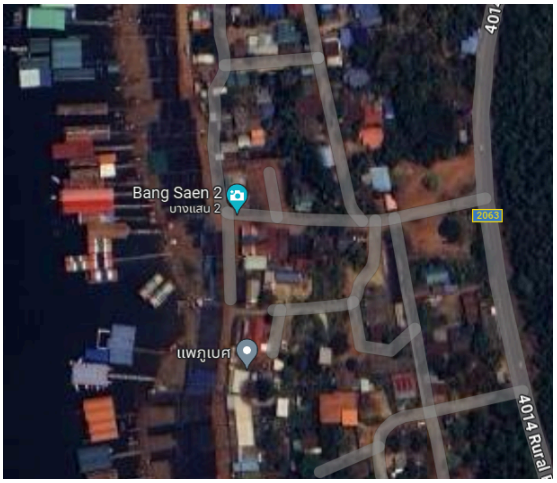

Figure 9. Satellite View of Bang Saen Song

Finding 3. Thematic analysis led to an overview of barriers to effective municipal waste management in the Khuean Ubolratana Subdistrict

We identified waste issues in the Khuean Ubolratana Subdistrict area through thematic coding based on 31 interviews conducted across eight MUNI and SAO sites. Appendix E.1 illustrates 28 codes organized into 6 themes.

(1) **Unregistered residents** are beyond the MSW budget covered by the Thai government.
(2) **Ineffective waste management processes** encompassing both waste management services provided by authorities and on-site residential sites.
(3) **Civic waste management behavior and participation,** focusing on observable locals' behaviors noted by the researchers.
(4) **Public awareness and attitude** are related to the discernible mindset of the locals regarding waste management.
(5) **Lack of Resources** refers to organizations needing more budget and human resources.
(6) **Bureaucratic constraints** occur with the authorities.

The frequency of mentions for each code was represented in bar graphs to identify the critical problems occurring in both MUNI and SAO areas, which are shown in Appendix E.2. In addition, the data was analyzed and presented in various types of graphs to explore correlations and gain further insights into the dataset as follows.

Finding 3.1. The pie charts illustrating themes offer an extensive overview and indicate the proportion of each theme of issues in MUNI and SAO

The pie charts below illustrate the themes mentioned by interviewees in MUNI (blue) and SAO (pink) separately.

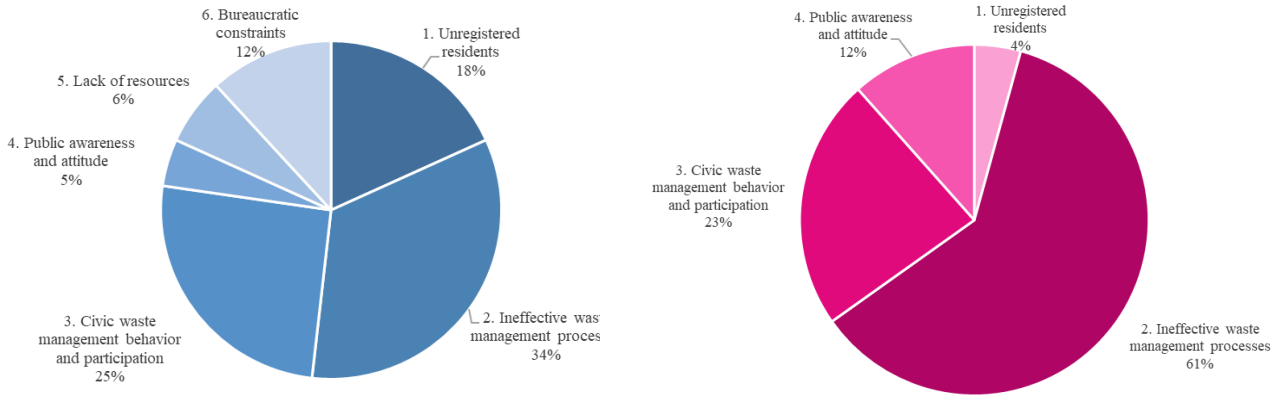

Figure 10. Pie Charts of Themes from Thematic Coding, Representing MUNI in Blue and SAO in Pink

The thematic analysis of interview responses from both MUNI and SAO revealed several key themes related to waste management. Ineffective waste management processes emerged as a predominant issue in both areas, with SAO highlighting this problem more prominently. Civic waste management behavior and participation showed similar proportions in both regions, indicating a consistent trend of significant challenges. Interestingly, MUNI had a significantly higher proportion of mentions regarding unregistered residents compared to SAO, suggesting a potentially greater occurrence of this issue in MUNI. Moreover, while themes like "Lack of resources" and "Bureaucratic constraints" were mentioned in MUNI, they were not mentioned in SAO. However, the absence of these themes in SAO does not necessarily imply their nonexistence; it may be due to factors such as the representation of officials in the interviews.

Finding 3.2. The graphs depicting the five key components of the MSW management system illustrate the level of concern for each component in both MUNI and SAO

Despite the themes, the overall codes were classified into five key components of the MSW management system, as shown in Appendix E.1. As illustrated in Figure 11, due to variations in the number of interviewees from each site, the data were converted into percentages for MUNI and SAO separately. This approach enabled us to observe the proportion of issues interviewees raised in each area.

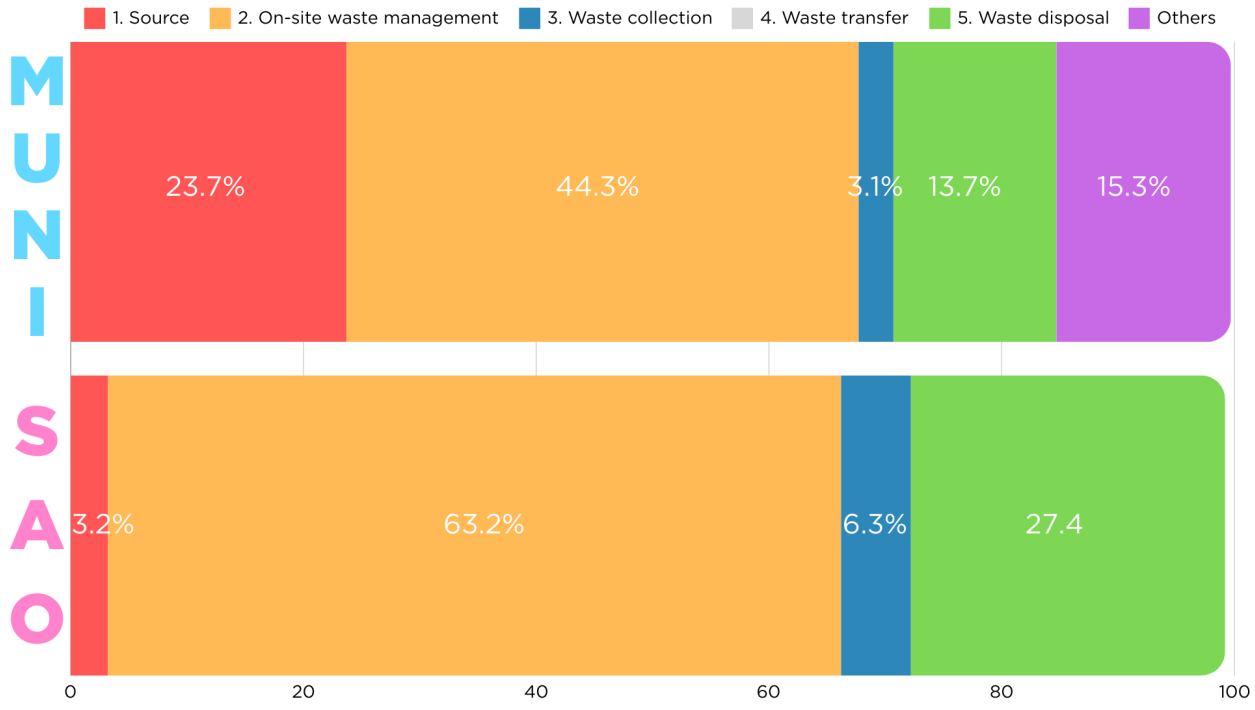

Figure 11. Graphic illustration of codes categorized in five key components of the MSW management system for MUNI and SAO

In both MUNI and SAO, on-site waste management was the most frequently mentioned issue, particularly prominent in SAO, suggesting a need for further exploration. In MUNI, the source and "others" will be discussed next, with waste disposal and collection being less concerning. Waste disposal received more attention in SAO than in MUNI, indicating more significant concern, while waste collection was more prominent. However, source-related issues were less mentioned in SAO, possibly due to lower perceived prominence than MUNI, reflecting population density differences. Moreover, the category "Others" was absent from the interviews, which, upon examining the codes, typically includes issues related to "Lack of resources" and "bureaucratic constraints." This data aligns with the absence of those themes in SAO, as depicted in the pie charts.

Finally, it is noteworthy that none of the interviewees from either organization mentioned waste transfer issues despite their significance in waste management. Moreover, the absence of waste transfer stations in MUNI and SAO underscores the importance of addressing this aspect. This lack of mention may indicate a need for more awareness or perceived importance regarding waste transfer among the interviewees.

Finding 3.3. The comprehensive graphs of MUNI and SAO offer insights into the correlation between the themes and key components of the MSW management system

We combined the pie charts representing themes with the graph depicting key components related to the issues, separately for MUNI and SAO, as shown in Figure 12 and Figure 13. This amalgamated examination facilitates a deeper exploration of the connection between the identified themes and key components. These graphs provide insights into how each theme influences the organizations' components. Similar fashions of the graphs in MUNI and SAO could be observed. First, the theme of ineffective waste management processes, being the most mentioned, impacted most of the key components. However, in SAO, none of the issues in this theme affected the source. The "Civic waste management behavior and participation" and "Public awareness and attitude" directly affected the on-site waste management. However, unregistered residents could also affect these two key components. Additionally, the themes "Lack of resources" and "Bureaucratic constraints" do not directly affect any one component but negatively impact all components, as categorized under "others".

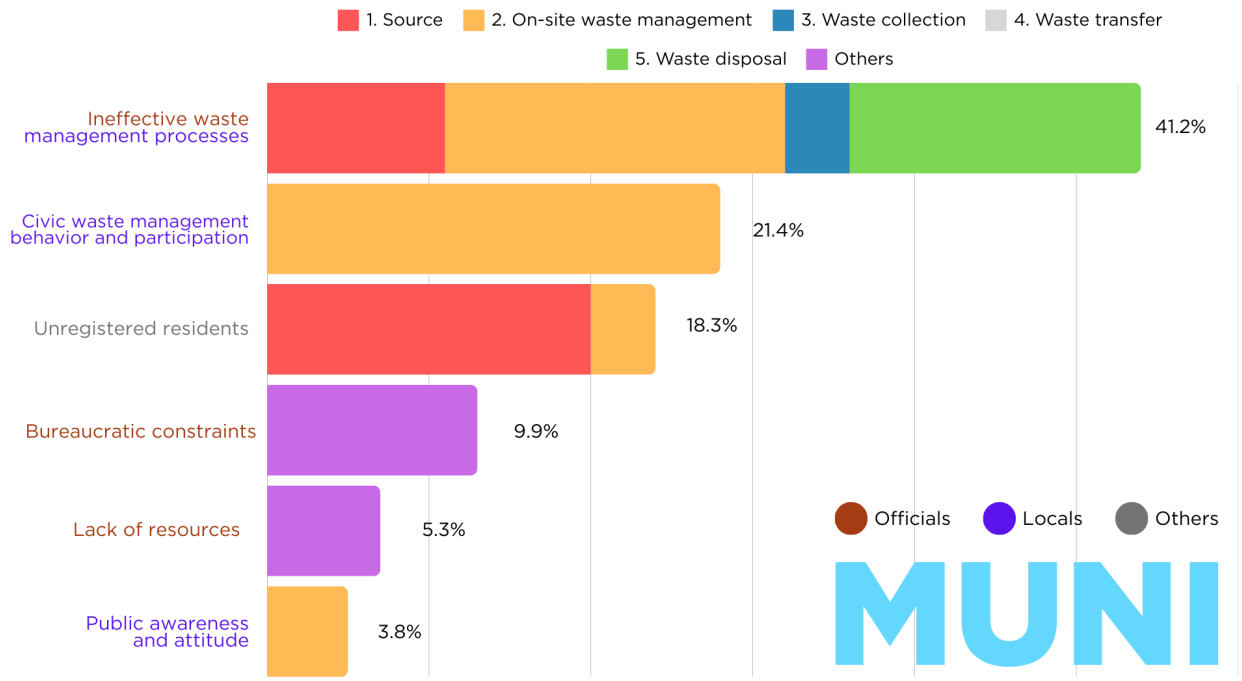

Figure 12. Graphic illustration of correlated themes and key components within the MUNI's MSW

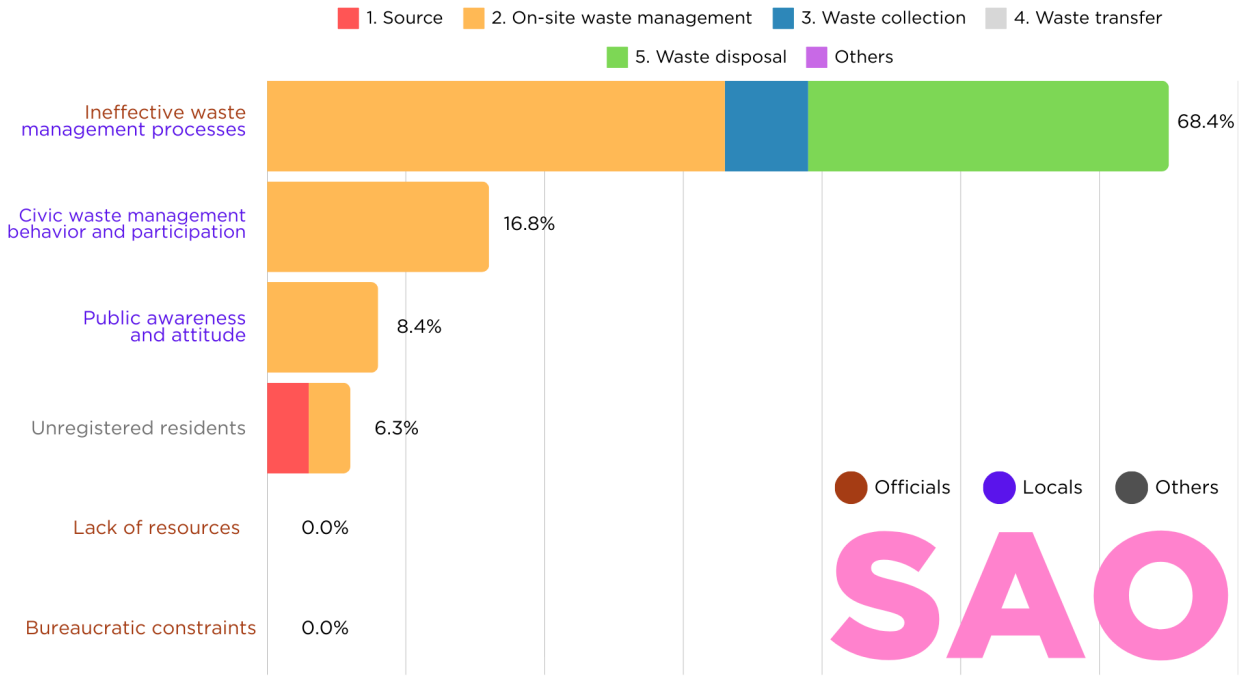

Figure 13. Graphic illustration of correlated themes and key components within the SAO's MSW

The graphic illustrations define problems in the eight sites we observed in the Khuen Ubolratana Subdistrict, which we will address in detail in the subsequent findings.

Finding 4. Waste situations recurring in Khuen Ubolratana Subdistrict were identified, indicating where the recommendations should be provided

Based on thematic coding analysis and direct observation, the waste issues and problems of eight sites in Khuean Ubolratana Subdistrict were identified and grouped according to the key components of the MSW management system. The summary results for waste situations across the eight sites, separated between MUNI (blue) and SAO (pink) areas, in Khuean Ubolratana Subdistrict, are presented in Figure 14. However, waste generated in M3 (Ubolratana Dam) is represented in purple, as it is managed by the Electricity Generating Authority of Thailand (EGAT), not by MUNI, despite being within MUNI's jurisdiction.

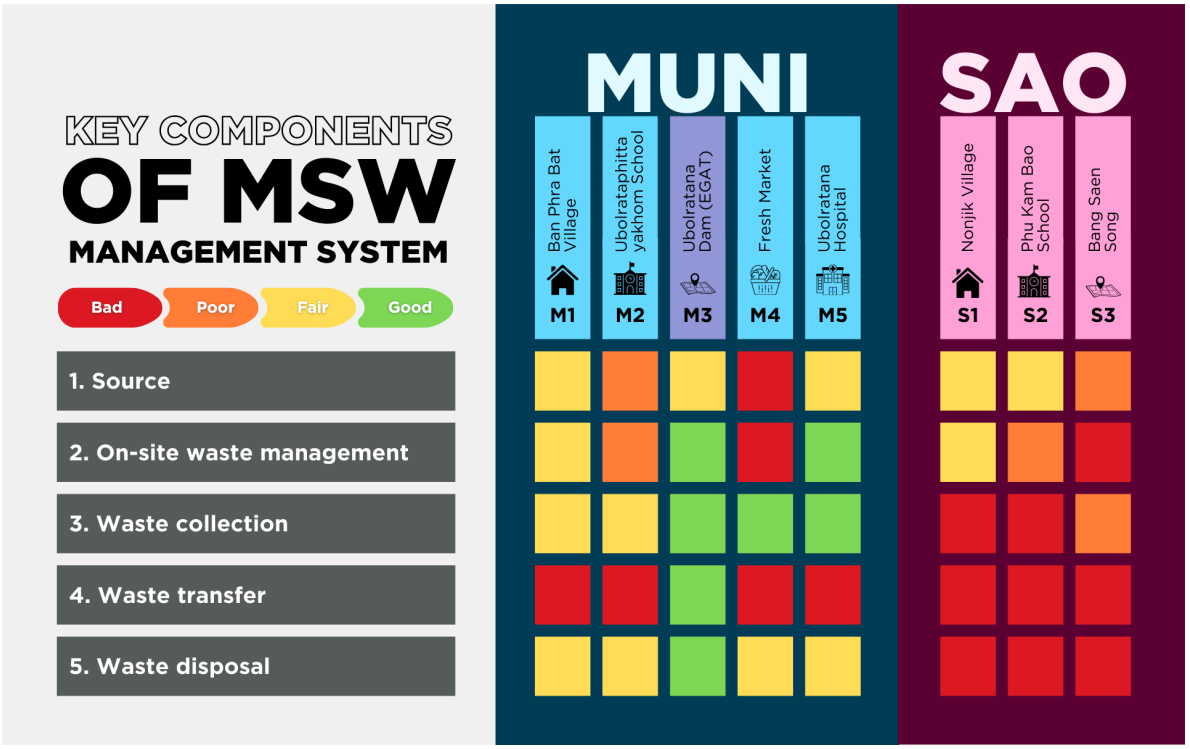

Figure 14. Problematic Issues of Waste Management Process in Khuean Ubolratana Subdistrict

The criteria for each color code are as follows: red indicates a bad status, orange denotes a poor condition, yellow signifies a fair situation, and green represents a good practice. Further details for each criterion were elaborated in Appendix F.

Finding 4.1. Densely populated areas overseen by MUNI and SAO face source and on-site waste management challenges

Beginning with the first key component, the source, it is evident that the densely populated areas like M2 (Ubolrataphittayakhom School), M4 (the fresh market), and S3 (Bang Saen Song) are grappling with large amounts of waste. Therefore, they need help managing this waste effectively to prevent subsequent issues with other key components.

For example, M2 school, a high school in the Ubolratana district, hosts approximately 1,300 students from Grade 10 to Grade 12 and students from neighboring areas outside MUNI. It is rated orange for its waste source, indicating a significant volume of waste generated by the activities of over a thousand individuals exceeding manageable capacity. This situation leads to adverse behaviors, such as improper waste dumping, as depicted in Figure 15.

Figure 15. Improper Waste Dumping in M2

However, the most critical issue, rated red, arose at M4 (Fresh Market). Being the only large fresh market in the district, it generates a substantial amount of waste due to its bustling nature. Moreover, the market faces challenges with out-of-area trash deliberately dumped in the vicinity, often mistaken for designated dumping spots due to trash being left on the street aisle by surrounding households to avoid dogs scavenging. This situation is reflected in Figure 16, exacerbated by dumping from unregistered residents in the thematic coding analysis.

Figure 16. Trash from Commuters in Front of the Market

In SAO, S3 (Bang Saen Song) faces similar challenges. This area, known for its bustling activities and owned by EGAT, has been entrusted to SAO's oversight. Despite its popularity among tourists and numerous restaurants, Bang Saen Song has a significant accumulation of waste. Consequently, it has been rated as orange due to the high volume of waste generated.

In short, the densely populated areas managed by MUNI and SAO have to deal with high waste volumes, highlighting the need for more effective plans or systems to address this challenge.

Finding 4.2. Ineffective waste segregation practices occur in MUNI, in contrast with SAO

While certain community members, such as those in M1 (Ban Phra Bat Village) and M5 (Ubolratana Hospital), actively participate in waste segregation, reports from officials and locals indicate low public involvement in the community waste separation process. According to the thematic coding, this issue was highlighted as MUNI's second most mentioned concern.

A notable site facing these challenges is M2 (Ubolrataphittayakhom School). Although effective processing of canteen food waste into fertilizers has been implemented, overall on-site waste management needs to improve. Despite attempts to introduce a waste bank policy, only plastic bottles could be collected due to limited space for waste storage and moderate community participation. Moreover, there needs to be more public involvement in the community waste separation process, with instances of waste dumping in public areas, primarily by students, due to outdated personal norms and lack of awareness.

The most critical situation by far is observed at M4 (Fresh Market), rated red. A notable lack of public involvement in waste segregation leads to insufficient sorting influenced by outdated norms. Only some recyclable waste is separated, and with the majority of waste generated in the market being organic, coupled with the high accumulation of waste, the unsorted waste significantly complicates waste management efforts.

Furthermore, sites experiencing a high accumulation of waste tend to encounter issues with on-site waste management, such as waste segregation. This is attributed to excessive waste exceeding management capabilities and needing an effective plan.

As reported in interviews and observed, SAO has better waste segregation practices than MUNI. This is attributed to effective waste management plans and strong village leadership, particularly in places like S1 (Ban Nonjik Village). Here, community members actively participate in waste separation initiatives due to the waste bank policy, which has been notably successful, as depicted in Figure 17. The financial incentive gained from selling segregated recyclable waste is a strong motivator for waste separation, which is well-received by the locals. Additionally, organic waste is utilized for fertilizer or animal feed, aligning with the agricultural activities of the community. Hazardous waste is also appropriately managed by placing it in designated bins, as shown in Figure 18, awaiting collection by the SAO for subsequent transport to PAO.

Figure 17. The Waste Bank Policy Implemented in Ban Nonjik Village from Direct Observation

Figure 18. The Drop-off Bins for Hazardous Waste in Ban Nonjik Village from Direct Observation

Currently, MUNI is implementing a waste bank policy similar to SAO's, with hopes for positive outcomes. However, managing organic waste, particularly in M4 (the fresh market), remains challenging for MUNI.

Finding 4.3. Improper waste disposal methods, such as open-air burning, are commonly practiced in SAO

As thematic coding results indicate, improper waste disposal methods, mainly open-air burning, are widespread in SAO communities. This practice is common among residents and officials, often disregarding environmental and public health concerns. Additionally, SAO's classification as a rural society community leads to significant agricultural waste generation, further contributing to open-air burning. Locals find this method convenient, as seen in interviews and observed in S1 (Ban Nonjik Village). The lack of proper waste disposal sites exacerbates the problem, with residents primarily managing waste. Only in S3 (Bang Saen Song) is waste occasionally collected and burned by officials.

Figure 19. The Waste Burning Spot in Ban Nonjik Village from Direct Observation

In addition to open-air burning, other improper waste disposal methods are also prevalent. For example, in S3 (Bang Saen Song), there needs to be more adequate waste containers in public areas, often washed away by flood tides, which leads tourists to dump trash on the streetsides. Furthermore, many workers or restaurant owners are unregistered or non-local, leading to non-compliance with SAO waste management protocols. As a result, residents often dump household waste in public open spaces or restricted areas, as depicted in Figure 20.

Figure 20. A local was throwing trash bags at a location labeled "Do Not Dump Trash" in Bang Saen Song from direct observation

It is important to note that MUNI also engages in these practices, albeit to a lesser extent than SAO.

These improper waste disposal methods contribute to air pollution and pose serious health risks to nearby communities, potentially leading to long-term health complications. Additionally, they emit greenhouse gases, contributing to climate change and environmental degradation. Addressing these issues immediately may prove challenging, given the current absence of a proper waste disposal site. Therefore, it is crucial to prioritize efforts to minimize these practices and explore alternative solutions.

Finding 4.4. Waste disposal sites directly impact the waste collection efforts in both MUNI and SAO

In Khuen Ubolratana Subdistrict, the absence of a dedicated waste disposal site owned or accessible by MUNI and SAO presents a challenge. As a solution, both entities have had to enter into contracts or memoranda of understanding (MOUs) with other governmental or private organizations to utilize their waste disposal facilities. MUNI has secured a contract with a waste-to-energy (WTE) plant located at Ban Kum Bon, enabling them to dispose of approximately 90 tons of waste each month. However, this capacity needs to be increased. Conversely, SAO recently initiated a contract with another WTE plant still under construction. Consequently, SAO currently needs a proper waste disposal site for its residents.

In MUNI, adherence to the quota of 90 tons per month for waste disposal necessitates strict control over the amount of waste collected. The weekly schedule for the waste collection remains fixed, even though more is needed in some areas. M2 (Ubolrataphittayakhom School) is particularly affected by this issue. MUNI's scheduled waste collection service once a week is inadequate for managing the waste generated by nearly 1,300 individuals, leaving a high amount of residual trash. Consequently, the school resorts to open-air burning practices every evening to dispose of the excess waste. Accessibility to collection services remains challenging in M1 (Ban Phra Bat Village). Thus, improper waste disposal practices also occur in this area, as shown in Figure 21, resulting in a yellow rating on waste collection for both locations.

Figure 21. The Waste Burning Spot in Ban Phra Bat Village from Direct Observation

Due to the absence of a proper waste disposal site in SAO, the waste collection service cannot be provided effectively, as there is no designated location to transport waste. This critical lack of infrastructure is the primary reason for the prevalence of improper waste disposal practices in the area.

Therefore, the presence of a proper waste disposal site with sufficient capacity is crucial for ensuring effective waste collection and reducing the occurrence of improper disposal practices.

Finding 4.5. Ubolratana Hospital plays a significant role in disposing of infectious waste within MUNI

M5 (Ubolratana Hospital) plays a critical role in managing infectious waste generated within MUNI by utilizing its incinerator for proper disposal. As a result, households in the MUNI area are instructed to segregate infectious waste and deliver it to the hospital for disposal. However, it is essential to highlight that the incinerator utilized for infectious waste disposal is underperforming, resulting in pollution and potential long-term health effects for individuals. Ideally, infectious waste management should be outsourced to a specialized service provider, but no such service is currently available. The hospital's remote location, which diverges from common service routes, makes it financially impractical for private companies to offer their services exclusively to the hospital due to the higher costs involved. Thus, the hospital continues to manage infectious waste internally despite the limitations of its incinerator.

Finding 4.6. The waste management system at Ubolratana Dam is highly effective

The Ubolratana Dam, under the jurisdiction of the Electricity Generating Authority of Thailand (EGAT), stands out for its exemplary waste management practices. With EGAT overseeing operations, the dam benefits from adequate budget and human resources, surpassing those available to MUNI. Consequently, the dam consistently earns green ratings across key components. Waste segregation bins are strategically placed, as shown in Figure 22, and various waste streams are managed effectively: organic waste is converted into fertilizer, hazardous waste is transferred to the PAO, and recyclable materials are sent to Nonsang Subdistrict Municipality through a MOU. Waste collection services are provided daily, and waste is sorted at the transfer station before dispatch, facilitating proper waste separation. This highlights the significance of waste transfer stations, which are absent in MUNI and SAO. Finally, waste is directed to the MSW Management Center for further processing, with no reported concerns about disposal methods during interviews.

The dam sets a high standard compared to other sites, excluding the hospital. Its success is a potential model for implementing similar practices in other areas, demonstrating the feasibility of adapting their methods for broader waste management improvement.

Figure 22. Well-Labeled Waste Segregation Bins at the Ubolratana Dam from Direct Observation

Finding 4.7. Lack of resources and bureaucratic constraints are the significant challenges in improving the waste management system in MUNI

The thematic analysis revealed that both "Lack of resources" and "Bureaucratic constraints" were mentioned to some extent in MUNI, indicating their impact on the waste management system. The absence of adequate budgetary allocations, manpower, and infrastructure impedes the development of comprehensive waste management programs. Specifically, the need for more human resources was emphasized as a significant concern, impacting the implementation of policies, such as the EM fertilizer policy, which had to be paused due to staff problems. Additionally, bureaucratic constraints impede progress in waste management practices, as evidenced by MUNI's low-quality garbage truck purchased due to organizational regulations.

While not explicitly mentioned in SAO, similar challenges may exist due to its shared governance structure and environmental context with MUNI. Therefore, collaborative efforts between MUNI and SAO are essential to address the need for more resources and bureaucratic constraints and develop sustainable waste management strategies.

Finding 5. Key findings from interviewing waste-related organizations and their implications to the case in Khuean Ubolratana Subdistrict

(1) Pollution Control Department

The team intended to obtain information on waste management policy in Thailand. The Pollution Control Department has a section that oversees waste management. The team has gained valuable insights that can be applied to the situations in Khuean Ubolratana Subdistrict.

The key takeaway the team received was an overview of the trend of how waste is currently treated in the country and the world. Upstream waste management is the area of focus, with it having the most impact on the amount of waste that can be treated. This means the design of products should be eco-friendly, such as using biodegradable materials that may need to be implemented in Khuean Ubolratana Subdistrict to ensure that waste generation is minimized as much as possible. Although important, improving the waste management system is needed to effectively deal with the increase in consumption of products and the inevitable waste that will be produced as a result. People should be encouraged to be responsible for their waste and reap its benefits instead of being punished for not doing so. Policies penalizing improper waste management should be less than rewarding efforts of correct waste management. Residents in Khuean Ubolratana Subdistrict should see the benefits of proper waste management and voluntarily participate in waste-related practices.

To conclude, the information obtained from this interview helped the team visualize the scale and complexity of waste management and what areas should be prioritized to have the most impact on the well-being of residents in the subdistrict.

(2) Rung Aroon School

Gaining insights from Rung Aroon School, which excels in waste management, provided valuable lessons and inspiration for implementing effective waste management practices elsewhere. By studying the methods and approaches employed by the school, we identified strategies that promote sustainability and reduce waste generation. Through this exploration, the team uncovered actionable insights and best practices that can contribute to building a more sustainable and environmentally conscious future for Khuean Ubolratana Subdistrict.

Everyone conducts proper waste management practices at the school. Recyclable items, like plastic bottles and foams, are carefully sorted. Then, they are either recycled or processed, so less waste goes to the dump. Food scraps like mango peels are separated and put into compost bins, as shown in Figure 23. There, microorganisms help break them down into substances good for the soil.

Figure 23. Compost Bins for Organic Waste at the School

The school goes beyond sorting and composting. It also ensures that the water from the school building and kitchen is cleaned before returning to nature. It does not just keep its good waste habits to itself but educates the nearby community. Parents and people nearby join in by sorting waste. By making waste management easy and getting everyone involved, Rung Aroon School sets a great example for caring for the environment together.

Though the Khuean Ubolratana Subdistrict has made some effort in waste management practices, many techniques from Rung Aroon School can be applied to the subdistrict to improve their on-site waste management in MUNI and SAO.

(3) Chulalongkorn University Zero Waste (Chula Zero Waste)

Chula Zero Waste aims to have a waste management system that can serve as a model for waste management in the university area. They aim to educate students, faculty, and staff at Chulalongkorn University to be equipped with knowledge, understanding, and awareness of waste reduction and segregation. The team has learned about various creative programs that Chula Zero Waste has been implementing in the past and how successful they were for both waste reduction and segregation in the university area.

For example, Chula Zero Waste has initiated a program that offers free water to those who bring their bottles, promoting sustainability by reducing single-use plastic consumption. The initiative fosters environmental consciousness, encourages hydration, and cultivates community engagement in waste reduction efforts by incentivizing reusable bottle use. This effective program demonstrates the power of small actions in creating a more eco-friendly campus and beyond.

Segregation bins are well placed across the campus; the types and numbers of bins presented are also very detailed, as shown in Figure 24. More than proper waste infrastructure is needed, as many other factors must be considered. Students and staff need to have a proper mindset for waste segregation for the efforts to be meaningful. Chula Zero Waste has found a way to deal with this issue by placing pre-sorted correct waste in the correct bin and showing how it is done so that people are more likely to follow along and rightfully dispose of their waste.

Figure 24. Waste Segregation Bins at Chulalongkorn University Campus

Chula Zero Waste serves as a beacon of sustainability in waste management, offering valuable lessons and inspiration for schools and communities seeking to enhance their environmental practices. By implementing innovative initiatives like incentivizing reusable bottle use, Chula Zero Waste demonstrates practical strategies that can be replicated and adapted in various educational settings. By following Chula Zero Waste's example, schools, particularly in the subdistrict, can strive to reduce waste and promote sustainability within their communities.

4.2 SWOT Analysis of the Official's Waste Management in Khuean Ubolratana Subdistrict

SWOT analysis of the official waste management in Khuean Ubolratana Subdistrict helped produce practical recommendations for enhancing waste management systems. The current waste management system was thoroughly examined by evaluating its strengths, flaws, possibilities, and dangers. The analysis helped identify strengths that could be harnessed, weaknesses that needed to be addressed, development opportunities, and potential dangers that might prevent growth. Understanding these characteristics enabled the creation of focused and viable solutions customized to the unique requirements of Khuean Ubolratana Subdistrict. As a result, SWOT analysis recommendations were more likely to be practical, actionable, and effective in optimizing waste management processes while encouraging environmentally conscientious behaviors.

4.2.1. SWOT Analysis of MUNI

Strength (S)	Weakness (W)
● **Experience** of municipal leaders actively addressing waste issues. ● **Recognition** of waste problems within the area. ● **Abundance of resources** compared to surrounding local government organizations. ● **Waste management education** is provided to residents, including information to village chiefs.	● **Limited** incinerator capacity (90 tons/month). ● **Need more** human resources. ● **Improper waste disposal practices** in the community. ● **Lack of trash sorting** by residents. ● **Waste generation exceeds** the area's capacity. ● **Underperforming** infectious waste disposal infrastructure at the hospital. ● **Inadequate waste storage** facilities. ● It is a challenge to **find external organizations for waste management services**. ● **Improper waste dumping** by locals. ● **Limited community engagement** and **awareness**.

Opportunities (O)	Threats (T)
● **Cooperation** with the Electricity Generating Authority of Thailand (EGAT) for solutions. ● Implementation of **technology** for improved waste management, i.e., waste-to-energy. ● Increasing waste management **awareness** within Thai society. ● Implement targeted public awareness **campaigns** to educate residents about responsible waste disposal and recycling.	● Presence of a significant **non-registered population**. ● **An influx of non-local** individuals for work contributes to waste challenges. ● **Unclear laws** and **unstructured policies.** ● **The hot spot area of Khon Kaen is** leading to increased waste from external sources. ● **Urbanization** in the Khuean Ubolratana Subdistrict. ● **Political ambiguity** affecting waste management initiatives. ● **Ineffective educational system** impacting waste awareness and practices.

Table 3. SWOT Analysis of MUNI

4.2.2. SWOT Analysis of SAO

Strength (S)	Weakness (W)
• Local policies promoting **recycling** have been in place for an extended period, contributing to public understanding. • Active **community participation** fosters shared responsibility for waste management. • The **community's agricultural nature** allows for recycling agricultural waste. • Manageable waste due to the **small size of the community.**	• **More waste collection points and a proper disposal site** need to be established. • **Burning** of waste is a common practice. • **Limited waste coverage** due to the expansive area. • **Unclear land jurisdiction** contributes to unclear waste management responsibilities. • Challenges with **dog scavenging** and **inconsistent trash** sorting in some areas. • **Government policies** need more adaptability for diverse community needs. • **Limited resources**, both budget and human, hamper waste management efforts. • Some residents need more consistent **adherence to authority policies**.
Opportunities (O)	**Threats (T)**
• **Collaboration** with Kud Namsai to create a Memorandum of Understanding (MOU) on Refuse-Derived Fuel (RDF). • **Partnership** with local businesses for additional resources and support, mainly due to the area's organic waste profile. • Implement targeted public awareness **campaigns** to educate residents about responsible waste disposal and recycling.	• **Growing urbanization** may lead to increased waste generation • **Overlapping area** and Local Administrative Organization (LAO) functions. • I**neffective educational systems** impacting waste awareness. • **Lack of collaboration** poses a threat to comprehensive waste management initiatives.

Table 4. SWOT Analysis of SAO

Chapter 5

Conclusion and Recommendation

As part of our comprehensive analysis of waste management systems in the Khuean Ubolratana Subdistrict, our team has identified key challenges and opportunities for improvement. Our investigation has uncovered several issues in the current waste management practices overseen by the MUNI and the SAO, including deficiencies in waste disposal infrastructure, inadequate waste segregation practices, and improper waste disposal methods. SWOT analyses were conducted for both organizations to comprehensively assess the situation to evaluate their internal capabilities and external factors concerning their waste management systems, as illustrated in Tables 4 and 5.

According to Finding 4, which identified recurring waste situations in the Khuean Ubolratana Subdistrict, waste collection is contingent upon waste disposal infrastructure. Although both components were rated red in the SAO sites, the MUNI currently hires an out-of-area WTE waste contractor to collect waste while waiting for the construction of the local WTE plant. Until the operation of the area WTE plant, efforts should focus on minimizing general waste accumulation to meet the monthly waste collection quota. Therefore, our recommendations primarily target the source, on-site waste management, and waste transfer. The recommendations cover all the key parts of waste management, as shown in the next section. They aim to provide various options for both officials to improve their current waste situations.

5.2. Recommendations for Improving Waste Management of the Officials

Based on our findings, we identified critical areas for improvement. We formulated recommendations according to the key components of MSW waste management, including the source, on-site waste management, waste transfer station, and waste transfer. These recommendations are detailed below.

5.2.1. Source

This critical component received a red rating primarily due to two main issues: the dumping of out-of-area trash from commuters and the high accumulation of waste, according to Finding 4.1. The following recommendations are provided to address each root cause effectively.

Recommendation 1: Tackling the influx of out-of-area trash from commuters

Intentionally dumping out-of-area trash has increased waste management costs and imposed limitations on MUNI's local waste quota. According to interviews, commuters without waste collection services in their area dump trash on the street aisle in front of the market, where MUNI provides waste collection services. However, this practice stems from surrounding households dumping their trash on the street aisle to prevent dogs from scavenging for food, indicating a mixture of organic waste. Sorting out organic waste may incentivize locals to keep their trash at home, alleviating out-of-area trash dumping. Therefore, the recommendations provided for on-site waste management can be applied to address this problem as well.

However, effectively implementing this approach requires concurrent public relations efforts with locals and commuters, stressing that streets are not for dumping. Raising awareness about proper waste disposal practices among both groups is essential to mitigate the out-of-area trash problem. Utilizing large, visible signs and direct communication methods, such as visiting surrounding households to explain the importance of proper waste disposal, can alleviate the problem. The village health volunteers (อสม.) could assist with this matter.

To enhance the effectiveness of this approach, undertaking a big cleanup of the area and its surroundings is crucial. Drawing from the case study of Ban Chum Het in Mueang Buri Ram District, Buri Ram, where a similar issue of out-of-area trash was addressed, implementing a Big Cleaning strategy proved effective in discouraging people from littering. Additionally, the collected waste was utilized to educate the community about proper waste separation and processing methods, fostering understanding and compliance with waste management practices (Pbs, 2019). Hence, cleaning up the area where trash is dumped may alleviate this problem.

Recommendation 2: Prevention of single-use plastic

The accumulation of waste in the hot spots is primarily due to its bustling nature, posing challenges in waste management. Nevertheless, certain types of waste are avoidable. According to insights gathered from the interview conducted by Chula Zero Waste, focusing on reducing single-use plastics can significantly decrease the volume of waste in the fresh market and its environmental impact. Chula Zero Waste serves as a notable case study, demonstrating the effectiveness of its waste prevention policy. By eliminating free single-use plastic bags and implementing a charge of 2 baht per plastic bag, they successfully reduced single-use plastic bag usage by 90% (Green News, 2018). Therefore, by adopting a similar policy, MUNI and SAO could significantly reduce waste quantities that adversely affect the environment on a larger scale. However, to make this strategy more applicable in a semi-rural setting, utilizing locally abundant natural materials or promoting bringing reusable bags could be explored through public outreach efforts.

5.2.2. On-site Waste Management

This crucial component's orange and red color rating is due to significantly low public participation in the community waste separation process, resulting in inadequate waste segregation driven by outdated personal norms. Furthermore, more waste containers must be placed in MUNI and SAO to promote proper waste dumping. These challenges have numerous adverse effects and require urgent attention. Therefore, we present recommendations for on-site waste management for both officials as follows.

Recommendation 3: Public relations in promoting public waste segregation

The market in MUNI and the restaurants in Bang Saen Song can be an example of how to enhance their on-site waste management. First of all, the most important part is to let each vendor know the procedure as well as the importance of waste segregation. Understanding the nature of the place, which is packed with people, each vendor should have a concise way to separate their waste, which is practical and straightforward. The vendor should only focus on separating their organic waste using a clearly labeled bag, preferably green, for consistency and to make it easier for them to see where the waste should go when working. The MUNI and SAO will then be able to collect the trash bags quite conveniently into two piles: black trash bags to send to WTE in the MUNI case and to be subjected to open-air burning for SAO, as they are already doing and the green trash bags containing organic waste, which will be elaborated later in the next section on the procedure of handling them.

Furthermore, MUNI and SAO can leverage various channels to announce the importance of waste sorting, including social media platforms, local newspapers, and community bulletin boards. Announcements can emphasize the significance of waste segregation in preserving the environment, reducing pollution, and promoting a healthier community. Also, with efficient waste segregation in the market, the out-of-area trash problem mentioned previously in the source section would be alleviated, as the area would have less trash.

Recommendation 4: Employment of waste segregation staff to utilize components of organic waste

Providing jobs to people in the area for waste separation can significantly impact the environment and the local community. Firstly, it creates opportunities in regions where job opportunities may be limited, thereby improving livelihoods and reducing poverty. Additionally, according to the case of Ban Takli in Nakhon Sawan province, this job should be praised as it is increasingly more critical in today's world, with more and more numbers and types of waste generated each year (Ban Takhli Municipality, 2021). They would handle the waste collected in the green bags to segregate the organic waste further and provide practical paths for each waste.

Finally, the workers can separate the organic waste discarded by the vendors into various valuable parts. These could be the vendors in the market of MUNI as well as vendors in Bang Saen Song, as they would primarily have organic waste to dispose of regularly. Organic waste, mainly food waste, holds significant potential for conversion into valuable resources. One example is composting, where organic waste such as fruit and vegetable scraps, coffee grounds, and eggshells are decomposed to create nutrient-rich compost. This compost can then enrich the soil in the area seen fit by the MUNI and SAO.

Moreover, certain food waste materials, such as animal bones, can be processed and repurposed for various applications. For example, bones can be ground into bone meal, a calcium-rich fertilizer to improve soil quality and promote plant growth. These valuable animal bones can then be sent to specific factories for further processing after separating them from the rest of the trash.

The waste to be separated is not limited to the ones mentioned, as many more depend on the waste generated in the market and the available options after the segregation process seen by both officials. The funds obtained from selling particular waste like animal bones could be returned to the places that sold them and provide a means for them to promote further good practices and buy necessary infrastructure like waste bins. This would ensure that the place would keep improving as time went by and eventually become a clean and sustainable place for the community in Khuean Ubolratana Subdistrict.

5.2.3. Waste Transfer

Recommendation 5: Implementing waste transfer station

A waste transfer station operated by the MUNI can be a hub for optimizing waste management processes. By separating collected trash again, this facility efficiently sorts the remaining waste besides the organic waste. Valuable materials are systematically sorted and processed for resale or can be utilized further as the MUNI approves. Moreover, hazardous or toxic waste can be identified and managed safely, mitigating environmental risks and ensuring compliance with regulations. Ultimately, these facilities play a vital role in ensuring the maximum waste sorting for the MUNI before finally sending them to the WTE plant. Lastly, following the success of utilizing a waste transfer station, valuable waste from SAO may also be processed here, which helps alleviate the waste situation in SAO while increasing the station's productivity in MUNI.

Several factors should be considered in successfully implementing a waste transfer station. The most important factor is the station's location. This location should be centralized following the waste collection route to minimize the distance of the garbage truck to the station. Proper staff training is also essential to ensure the safe waste transfer from collection to the station.

5.2.4. Waste Disposal

Recommendation 6: Adjusting waste collection routes and implementing MOU for proper waste disposal sites

As mentioned, SAO needs more proper waste disposal sites. However, although there is a WTE plant accessible by the MUNI, the distance from it to the plant is quite far and inconvenient.

Factors such as waste collection routes should be considered, especially in MUNI. As shown by the map in Figure 6, most of the important sites in MUNI are packed together. Route planning can be simplified by creating compact routes covering multiple nearby collection points. Collection schedules can be tailored to suit the concentrated waste generation, with more frequent pickups. Regular reviews and adjustments based on feedback can further enhance efficiency in waste collection practices.

In SAO, where there is no waste disposal site due to ongoing construction, it is crucial to prioritize waste minimization efforts. Recommendations 2-4 are particularly beneficial in addressing this issue. Implementing these recommendations aims to reduce the amount of waste burned in the open air. This practice not only adversely affects the residents but also harms the environment of Khuean Ubolratana Subdistrict.

5.3. Conclusion

In conclusion, the research project aimed to address waste management issues in Khuean Ubolratana Subdistrict through thorough data analysis and investigation. The objectives were to understand the current waste management system, compare it with benchmark systems, identify problems, and propose potential solutions.

Through interviews, observations, and analysis, several key findings emerged. The waste management approaches of the MUNI and SAO were analyzed, revealing similarities in upstream waste management protocols and differences in infrastructure. Mapping and thematic analysis provided further insights into waste situations across different areas, highlighting issues like ineffective waste management processes, lack of Public awareness and attitude, and resource limitations, particularly evident in M2 (Ubolrataphittayakhom School), M4 (Fresh Market), and S3 (Bang Saen Song). The limitations of proper waste disposal sites, including restricted quotas in MUNI and the absence of such sites in SAO, have emerged as a significant challenge. This deficiency has led to improper waste disposal practices, such as open burning and dumping, exacerbating environmental and health concerns within the community, and the discontinuation of SAO waste collection service. Interviews with waste-related organizations shed light on broader waste management trends and successful practices, offering valuable lessons for improvement.

Based on these findings, recommendations were proposed for the officials responsible for waste management in the area. Firstly, we propose tackling the dumping of out-of-area trash from commuters by incentivizing locals to keep their trash at home through effective waste segregation and public relations efforts to raise awareness about proper waste disposal practices. Additionally, a big cleanup of the dumping area and its surroundings can help deter further littering. Secondly, we advocate for implementing a single-use plastic reduction policy, drawing inspiration from the success of Chula Zero Waste in drastically reducing single-use plastic bag usage to minimize the volume of waste in the area. Thirdly, we emphasize the importance of public relations in promoting waste segregation among vendors and consumers in the fresh market and the restaurants in Bang Saen Song. Clear communication channels and educational campaigns can encourage active participation in waste segregation practices, enhancing overall waste management effectiveness. Fourthly, we recommend employing waste segregation staff to facilitate the proper sorting and processing of organic waste discarded by vendors. These workers can help create valuable resources from organic waste, such as compost and bone meal, contributing to a more sustainable waste management system. We propose establishing a waste transfer station to optimize waste management processes and ensure maximum waste sorting before disposal. Proper location selection and staff training are crucial for the successful operation of this facility, which plays a vital role in managing hazardous waste and complying with regulations. Finally, due to the considerable distance to MUNI's waste disposal, our suggestion to MUNI involves optimizing waste collection routes by considering the clustering of key locations, leading to more efficient routes and customized schedules. Conversely, in SAO, the absence of a waste disposal site due to construction underscores the importance of prioritizing waste minimization efforts to mitigate open-air burning, which poses risks to residents and the local environment.

In conclusion, the research project comprehensively analyzed waste management issues in Khuean Ubolratana Subdistrict and offered actionable recommendations for improvement. We strongly believe that by implementing these recommendations and learning from successful initiatives, the community can work towards a more sustainable and environmentally conscious future.

Bibliography

1. UNEP. (n.d.). *Solid waste management.* https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities/solid-waste-management

2. Thai PBS. (2019). “บิ๊กคลีนนิ่ง” กลยุทธ์หยุดจุดดูดขยะชุมชน. Thai PBS. https://www.thaipbs.or.th/news/content/286694

3. Ban Takhli Municipality. (2021). “พนักงานเก็บขยะ” อีกอาชีพที่สำคัญและไม่ควรมองข้าม https://www.takhlicity.go.th/news/detail/62027

4. University of Tartu. (n.d.). *MOOC: Auditing Waste Management*. https://sisu.ut.ee/waste/book/11-definition-and-classification-waste

5. Prysmian Group. (n.d.). *The importance of waste management*. https://www.prysmiangroup.com/en/insight/sustainability/the-importance-of-waste-management

6. Chen, Y. C. (2018). *Effects of urbanization on municipal solid waste composition. Waste Management*. https://doi.org/10.1016/j.wasman.2018.04.017

7. Bruna, A. (2023). *Topic: Waste generation worldwide*. https://www.statista.com/topics/4983/waste-generation-worldwide/#topicOverview.

8. Statistia. (2023). *Environmental pollution in Thailand - statistics and facts*. https://www.statista.com/topics/9203/environmental-pollution-in-thailand/#topicOverview

9. Somani, P. (2023). *Health Impacts of Poor Solid Waste Management in the 21st Century. Solid Waste Management - Recent Advances, New Trends and Applications*. https://doi.org/10.5772/intechopen.1002812

10. Yogalakshmi. K. N. (n.d.). *Solid waste disposal, open dumping and landfills – Solid and Hazardous Waste Management*. https://ebooks.inflibnet.ac.in/esp11/chapter/solid-waste-disposal-open-dumping-and-landfills/

11. Jakkrapan. N. (2014). *Khon Kaen biggest rubbish dump in NE. Bangkok Post*. https://www.bangkokpost.com/thailand/general/439413/khon-kaen-biggest-rubbish-dump-in-ne

12. Pollution Control Department (2021). *คู่มือสำหรับผู้บริหารองค์กรปกครองส่วนท้องถิ่น การจัดการขยะมูลฝอยชุมชนอย่างครบวงจร*. https://www.pcd.go.th/publication/499

13. Public Health Act (2017). *Thai government gazette, 109*. https://laws.anamai.moph.go.th/th/act-of-doh/download/?did=204256&id=71576&reload

14. Determining Plans and Process of Decentralization to Local Government Organization Act (1999). *Thai government gazette, 116*. https://odloc.go.th/wp-content/uploads/2021/02/Determining-Plans-and-Process-of-Decentralization-to-Local-Government-Organization-Act-B.E.-2542-1999.pdf

15. *The 2nd National Action Plan on Waste Management in Thailand*. (2023). EXRIASIACO.,LTD. https://www.exri.co.th/post/the-2nd-national-action-plan-on-waste-management-in-thailand

16. Saleh, H. M., & Koller, M. (2019, July 24). *Introductory Chapter: Municipal Solid Waste. IntechOpen eBooks*. https://doi.org/10.5772/intechopen.84757

17. Stewart, R. (2010). *Waste Management. ScienceDirect*. https://www.sciencedirect.com/topics/chemistry/waste-management

18. Thongyou, M., Chamaratana, T., Phongsiri, M., & Sosamphanh, B. (2014). *Perceptions on Urbanization Impact on the Hinterlands: A Study of Khon Kaen City, Thailand. Asian Social Science*. https://doi.org/10.5539/ass.v10n11p33

19. UCRSEA (n.d). *KHON KAEN THAILAND*. https://www.tei.or.th/thaicityclimate/public/research-29.pdf.

20. Team, T. S. (2022). *ชัชชาติ เปิดโครงการ 'ไม่เทรวม' นำร่องแยกขยะ 10 เส้นทาง 3 เขต. THE STANDARD*. https://thestandard.co/chadchart-trash-campaign/

21. Richards, D. R., Law, A., Tan, C., Shaikh, S., Carrasco, L., Jaung, W., & Oh, R. R. Y. (2020). *Rapid urbanization in Singapore causes a shift from local provisioning and regulating to cultural ecosystem services use. Ecosystem Services*. https://doi.org/10.1016/j.ecoser.2020.101193

22. Zhou, J., Li, L., Wang, Q., Van Fan, Y., Liu, X., Klemeš, J. J., Wang, X., Tong, Y. W., & Jiang, P. (2022). *Household waste management in Singapore and Shanghai: Experiences, challenges and opportunities from the perspective of emerging megacities*. Waste Management.

    https://doi.org/10.1016/j.wasman.2022.03.029

23. Green News. (2018). *ถอดบทเรียน Chula Zero Waste "เก็บค่าถุงพลาสติก ถึงลดขยะได้"*. https://mgronline.com/greeninnovation/detail/9610000068055

Appendix A: Comparison of Receipts Between the MUNI and the SAO According to the Official Document of the Fiscal Year B.E. 2567 (2023) Budget for Both Local Administrative Organizations.

Subject	Khuean Ubolratana Subdistrict Administrative Organization			Khuean Ubolratana Subdistrict Municipality		
	Act. 2565 THB	Est. 2566 THB	Est. 2567 THB	Act. 2565 THB	Est. 2566 THB	Est. 2567 THB
Revenue	188,301.72	184,260.00	415,250.00	2,584,344.18	2,970,000.00	3,200,000.00
Allocated from the government	16,694,050.88	15,815,740.00	17,932,950.00	23,587,006.87	25,030,000.00	25,300,000.00
Supported from the government	10,239,546.06	11,000,000.00	11,251,800.00	20,578,975.00	25,000,000.00	24,500,000.00
Grand total	27,121,898.66	27,000,000.00	29,600,000.00	46,750,326.05	53,000,000.00	53,000,000.00

Figure 25. Budget Receipts Between the MUNI and SAO

Appendix B: Interview Question

B.1. Questions for Authorities Working in the MUNI and the SAO in the Khuean Ubolratana Subdistrict Regarding the Working Procedure of Both Organizations

1) Can you provide information about the population within your responsibility community in the Khuean Ubolratana Subdistrict?

   อยากทราบจำนวนประชากรในพื้นที่อบต / ทตตำบลเขื่อนอุบลรัตน์

2) Can you provide an overview of your responsibility community's current waste management system in the Khuean Ubolratana Subdistrict?

   ในพื้นที่อบต / ทต มีระบบการจัดการขยะอย่างไร

3) What are the primary methods (guidelines) used for waste collection in the community?

   a) How is household waste currently collected in the subdistrict? (downstream)

   แนวทางการเก็บรวบรวมขยะในพื้นที่เป็นอย่างไรในภาพรวม และสำหรับขยะในครัวเรือนเป็นอย่างไร

4) Could you describe your upstream and midstream (reusing) waste management policy? Is there any specific policy you use?

   การจัดการขยะต้นทางและกลางทางตามกรอบแนวคิดในแผนปฏิบัติงานการจัดการขยะระดับประเทศฉบับล่าสุด ในพื้นที่เป็นอย่างไร

5) Are there specific waste management methods employed for the different types of waste (e.g., recyclables, organic waste)?

   สำหรับขยะแต่ละประเภท อาทิ ขยะรีไซเคิล ขยะอินทรีย์ มีวิธีการจัดการขยะ ตั้งแต่เก็บรวบรวม ขนส่ง กำจัด ที่แตกต่างกันหรือไม่

6) What are the most common types of waste? And which types are the hardest to manage?

   ขยะประเภทใดที่พบมากที่สุดในพื้นที่ และขยะประเภทใดจัดการยากที่สุด

7) Where is the collected waste typically disposed of or processed? (downstream)

   a) Are there designated landfill sites or waste treatment facilities?

   ปกติแล้วขยะที่ถูกเก็บรวบรวมมาจะถูกนำมากำจัดหรือแปรรูปต่ออย่างไร และในพื้นที่อบต / ทต มีสถานที่กำจัดขยะ อาทิ บ่อขยะ เป็นของตัวเองหรือไม่

8) What are the main challenges or issues in the current waste management system?

    a) Ask the SAO: We have heard that this area still needs more supportive waste management, such as no trucks. How is the situation right now? What were the causes?

    b) Are there any specific difficulties faced regarding collection, transportation, or disposal?

ปัญหาที่พบในการจัดการขยะในพื้นที่คือ?

(อบต) ได้รับข้อมูลมาว่าในบางพื้นที่อบตยังขาดระบบการจัดการขยะที่ซัพพอร์ตคนในพื้นที่ อยากทราบว่าสถานการณ์ตอนนี้เป็นอย่างไรบ้าง

9) Are there community engagement programs in place to promote responsible waste disposal?

มีกิจกรรมเกี่ยวกับการจัดการขยะที่เน้นการมีส่วนร่วมของคนในชุมชน เพื่อปลุกจิตสำนึกของประชาชนหรือไม่

10) Does the community dispose of waste using the method according to the policy/guideline provided by the authority?

ประชาชนปฏิบัติตามมาตรการจัดการขยะของอบต / ทต หรือไม่

11) What budget is allocated for waste management in the Khuean Ubolratana Subdistrict?

มีการจัดสรรงบประมาณสำหรับการจัดการขยะอย่างไรบ้างในเขื่อนอุบลรัตน์

12) Are there any resource constraints that impact the effectiveness of waste management efforts?

มีข้อจำกัดด้านทรัพยากรที่ส่งผลต่อประสิทธิภาพของการจัดการขยะหรือไม่

13) Are there any upcoming plans or initiatives to enhance the waste management system?

มีแผนที่จะมีการปรับปรุงหรือพัฒนาระบบการจัดการขยะในอนาคตหรือไม่

B.2. Questions for the Community Members Within the Responsibility of the MUNI and the SAO in the Khuean Ubolratana Subdistrict.

1) How do you currently dispose of your household waste in the community?

   โดยปกติคุณทิ้งขยะอย่างไรในชุมชนของตัวเอง?

   a) Are there any specific places where waste is commonly discarded?

      โดยปกติแล้วมีสถานที่สำหรับทิ้งขยะในชุมชนเลยไหม?

2) What are your thoughts on the current waste management system in your authority's responsibility community?

   มีความคิดเห็นอย่างไรต่อระบบการจัดการขยะในชุมชนที่ดูแลโดยหน่วยงานรัฐที่รับผิดชอบ?

   a) Are there aspects of the system that you believe could be improved?

      มีส่วนไหนของระบบการจัดการขยะที่คิดว่าจะต้องถูกพัฒนาไหม?

3) Are there specific challenges or issues you face in managing your waste?

   มีความท้าทายหรือปัญหาอะไรที่คุณพบเจอเกี่ยวข้องกับการจัดการขยะของคุณไหม?

4) How satisfied are you with the community waste management practice?

   รู้สึกพอใจแค่ไหนกับการจัดการขยะในชุมชนของตัวเอง?

   a) How would you describe the level of cooperation among community members in waste management efforts?

      ถ้าต้องให้คะแนนระดับความร่วมมือของคนในชุมชนในเรื่องความตั้งใจและพยายามของการจัดการขยะให้เป็นระบบ จะให้คะแนนเท่าไหร่?

   b) Are there community-led initiatives to promote responsible waste disposal?

      ในชุมชนมีผู้นำที่คอยกระตุ้นให้คนเริ่มมีความรับผิดชอบต่อการทิ้งขยะอย่างเป็นระบบไหม?

5) Have you noticed any differences in how waste is managed in your community compared to neighboring communities?

   คุณได้สังเกตเห็นถึงความแตกต่างของการจัดการขยะระหว่างในชุมชนของคุณกับ ในชุมชนเพื่อนบ้านอื่นๆหรือไม่?

6) Do community members have opportunities to provide input or feedback on waste management decisions

คนในชุมชนมีโอกาสได้ให้ข้อเสนอแนะหรือความเห็นของตัวเองในเรื่องของการจัดการขยะในชุมชนหรือไม่?

a) Are there concerns or inconveniences related to waste disposal that you want to highlight?

   มีข้อกังวลหรือเรื่องไม่สะดวกใจเรื่องไหนเป็นพิเศษในเรื่องของการจัดการขยะที่อยากกล่าวถึงไหม?

b) How does the current waste management system affect your daily life and living environment?

   ระบบการจัดการขยะในชุมชนในปัจจุบันมีผลกระทบต่อการใช้ชีวิตประจำวันและสิ่งแวดล้อมรอบตัวคุณอย่างไรหรือไม่?

c) How would you like to be involved in shaping waste management policies in your area?

   คุณอยากมีส่วนร่วมในการกำหนดนโยบายระบบการจัดการขยะในชุมชนของคุณหรือไม่อย่างไร?

7) How informed do you feel about the impact of improper waste disposal on yourself and the environment?

   คุณรู้สึกว่าตัวคุณได้รับข่าวสารหรือความรู้ในเรื่องผลกระทบที่เกิดขึ้นจากการจัดการขยะที่ไม่เหมาะสมต่อทั้งตัวคุณและสิ่งแวดล้อมขนาดไหน

Appendix C: Consent Letter Forms

C.1. The Consent Letter Form is Made for the MUNI and the SAO Officers Responsible for the Waste Management in the Communities in Khuean Ubolratana Subdistrict.

Hello,

We are a group of students from the Faculty of Science in Applied Chemistry, Chulalongkorn University completing our Interactive Science and Social Project (ISSP). Our team consists of four third-year undergraduate students and two Singapore exchange students completing the ISSP1 at Chulalongkorn University: Kittipit Maruthaphongsathorn, Zehra Tinwalla, Pimnapat Supmee, Phanpanadda Lertamornmongkol, Adithep Srichawla, Gabriella Roselyn, and Seow Yu Xuan. The Ubolratana Hospital Foundation sponsors us. Our research project aims to investigate issues in household waste management and the perspective of the local communities of the Subdistrict Municipality and the Subdistrict Administrative Organization in the Khuean Ubolratana Subdistrict, Khon Kaen Province, Thailand. The aim is to identify whether household waste is managed differently in neighboring communities and how it affects community waste disposal methods of choice and community well-being.

We invite you to participate in the interview regarding our research project to gather direct information on waste management within the communities in Khuen Ubolratana Subdistrict, which is under the responsibility of both the Subdistrict Municipality and the Subdistrict Administrative Organization. We seek to collect information regarding your current waste management policy. We would also like to gain insights into the collection method, disposal processes, and the organization's existing challenges. This interview should take about an hour of your time.

The information that you disclose during this interview will be used to direct further research and otherwise advance our project. The interview will be recorded digitally upon your consent. Please remember that this interview process is entirely voluntary, and you may choose not to participate. Should we ask a question you do not want to answer, you may skip it. You are invited to ask questions about the interview before it begins and review anything we quote from your interview before publication. Please email us below if you have any questions or concerns following the interview.

We will begin the interview by verbally stating your full name and consent.

Best,

ISSP1: Kittipit Maruthaphongsathorn, Zehra Tinwalla, Pimnapat Supmee, Phanpanadda Lertamornmongkol, Adithep Srichawla, Gabriella Roselyn, Seow Yu Xuan

Chulalongkorn University

Email: bsac.issp1.2023@gmail.com

For more information about this research or the rights of research participants, or in case of research-related injury, contact: ISSP 1 (see email above); Our advisor (Siripastr Jayanta, Email: Siripastr.Ja@chula.ac.th; Numpon Injin, Email: Numpon.I@chula.ac.th; Patompong Leksomboon, Email:patomple@gmail.com)

C.2. The Consent Letter Form is Made for the Community Members Within the Communities Responsible by the MUNI and the SAO in Khuean Ubolratana Subdistrict.

Hello,

We are a group of students from the Faculty of Science in Applied Chemistry, Chulalongkorn University completing our Interactive Science and Social Project (ISSP). Our team consists of four third-year undergraduate students and two Singapore exchange students completing the ISSP1 at Chulalongkorn University: Kittipit Maruthaphongsathorn, Zehra Tinwalla, Pimnapat Supmee, Phanpanadda Lertamornmongkol, Adithep Srichawla, Gabriella Roselyn, and Seow Yu Xuan. The Ubolratana Hospital Foundation sponsors us. Our research project aims to investigate issues in household waste management and the perspective of the local communities of the Subdistrict Municipality and the Subdistrict Administrative Organization in the Khuean Ubolratana Subdistrict, Khon Kaen Province, Thailand. The aim is to identify if household waste is managed differently in neighboring communities and how it affects community waste disposal methods of choice and community well-being.

We invite you to participate in the interview regarding our research project to gather direct information related to waste management within the communities in Khuen Ubolratana Subdistrict under the responsibility of both the Subdistrict Municipality and the Subdistrict Administrative Organization. We seek to collect information regarding your perspective on waste management in your community and the effects of the management on the community's well-being, such as the behavior in disposing of waste. This interview should take about an hour of your time.

The information that you disclose during this interview will be used to direct further research and otherwise advance our project. The interview will be recorded digitally upon your consent. Please remember that this interview process is entirely voluntary, and you may choose not to participate. Should we ask a question you do not want to answer, you may skip it. You are invited to ask questions about the interview before it begins and review anything we quote from your interview before publication. Please email us below if you have any questions or concerns following the interview.

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For more information about this research or the rights of research participants, or in case of research-related injury, contact: ISSP 1 (see email above); Our advisor (Siripastr Jayanta, Email: Siripastr.Ja@chula.ac.th; Numpon Injin, Email: Numpon.I@chula.ac.th; Patompong Leksomboon, Email:patomple@gmail.com)

Appendix D: Flowchart of the MSW Process Analysis

D.1. Flowcharts of the Waste Management Protocol Proposed by the MUNI and SAO in Khuean Ubolratana Subdistrict

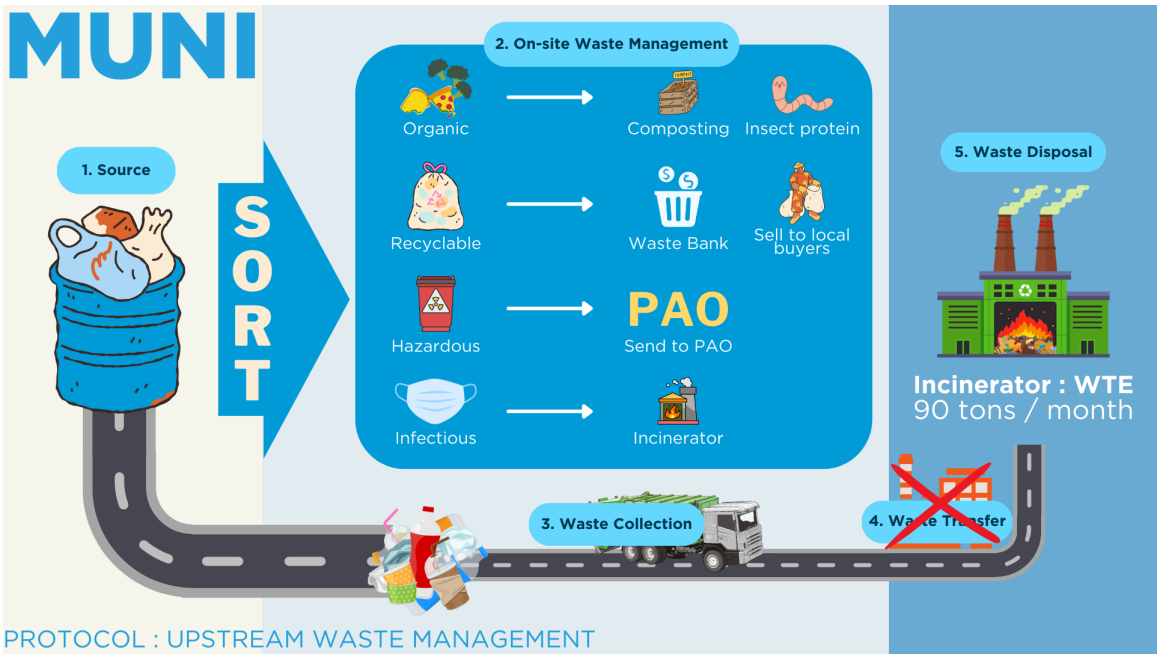

Figure 26. Flowchart of the Waste Management Protocol of the MUNI

Figure 27. Flowchart of the Waste Management Protocol of the SAO

D.2. Flowcharts of the Waste Management Practices for Each Specific Area Done by the Community Members Within Khuean Ubolratana Subdistrict

D.2.1. Residential Area

Figure 28. Flowchart of Waste Management System in Ban Phra Bat Village

Figure 29. Flowchart of Waste Management System in Ban Non Jik Village

D.2.2. School Area

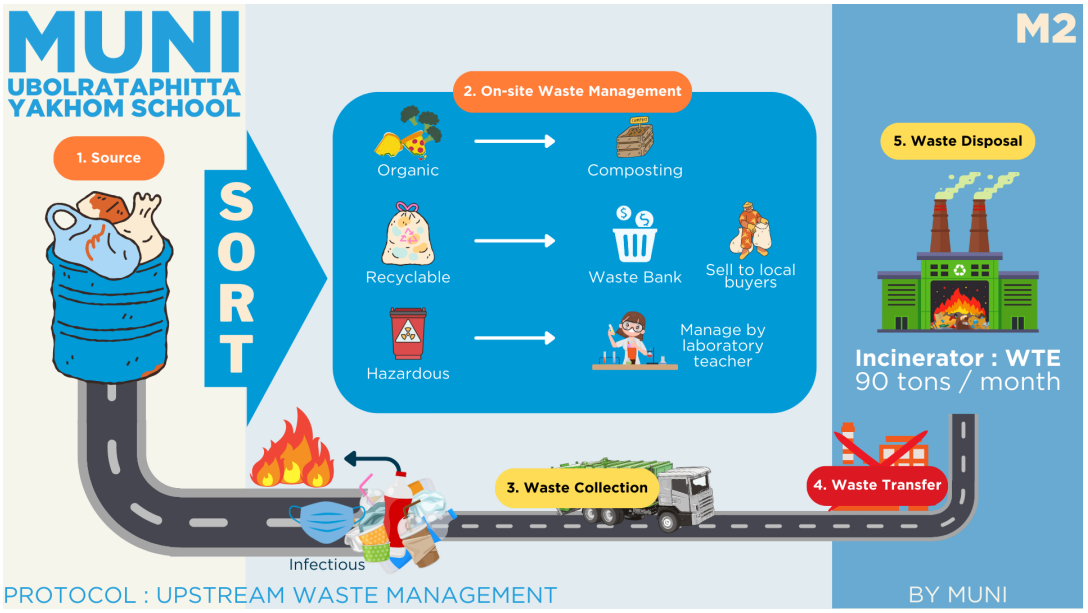

Figure 30. Flowchart of Waste Management System in Ubolrataphittayakhom School

Figure 31. Flowchart of Waste Management System in Phukambao School

D.2.3. Tourist Area

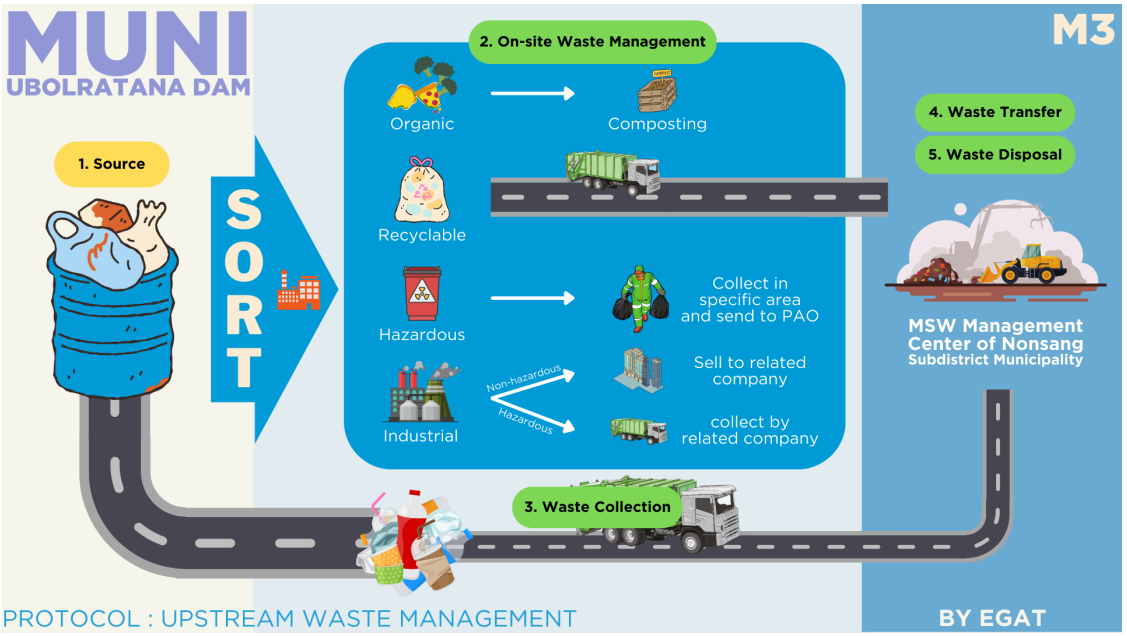

Figure 32. Flowchart of Waste Management System in Ubolratana Dam

Figure 33. Flowchart of Waste Management System in Bang Saen Song

D.2.4. Market Area

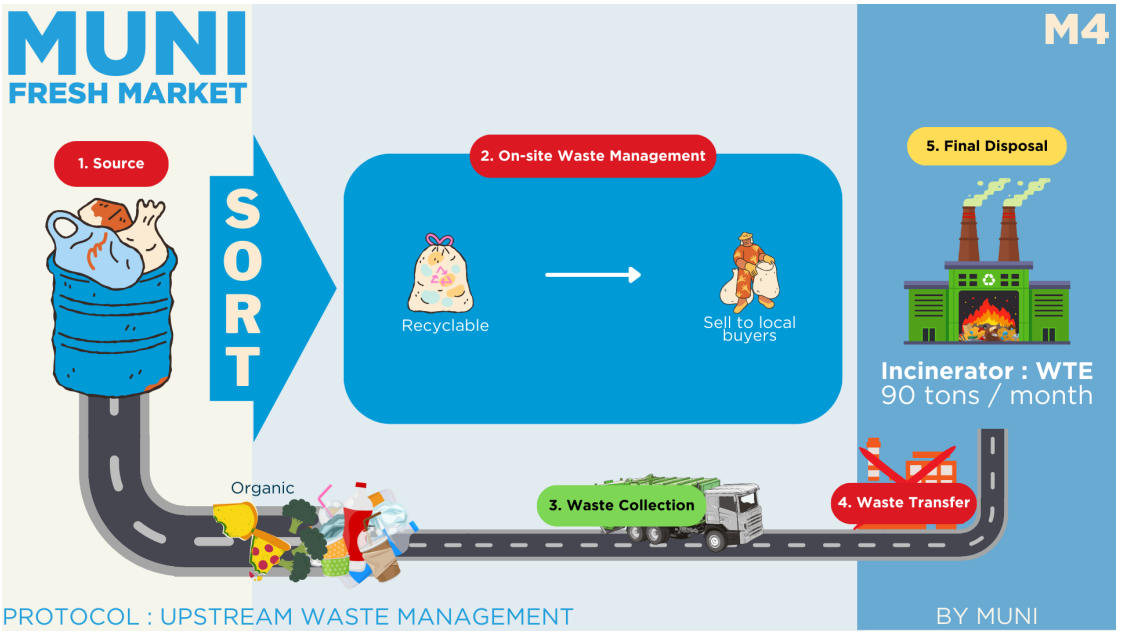

Figure 34. Flowchart of Waste Management System in Khuean Ubolratana Subdistrict Municipality Fresh Market

D.2.5. Hospital Area

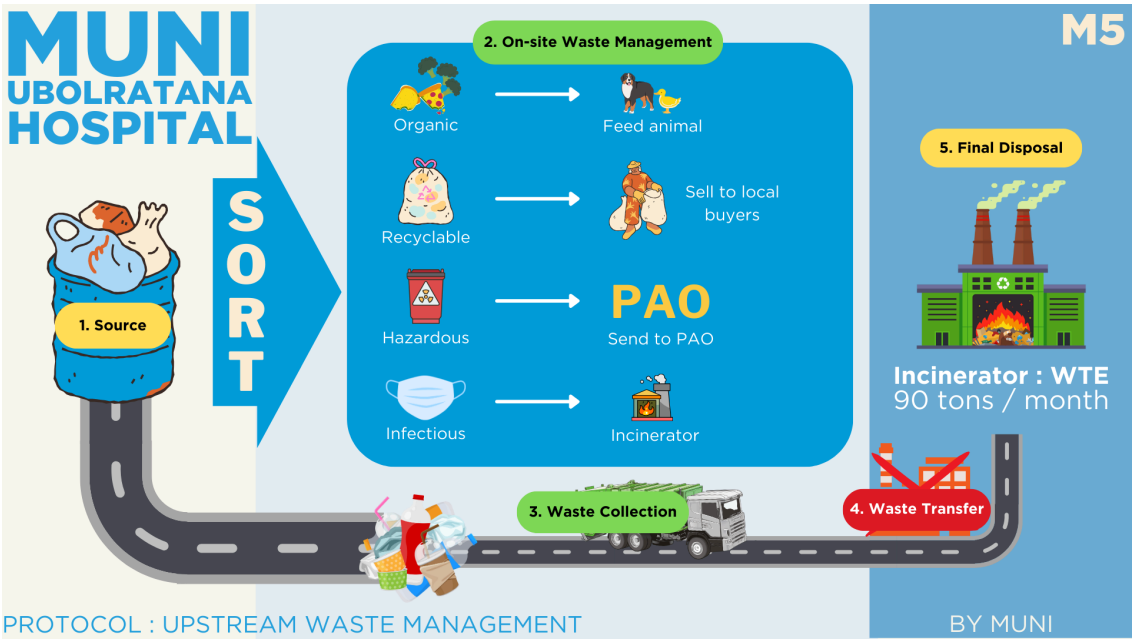

Figure 35. Flowchart of Waste Management System in Ubolratana Hospital

Appendix E: Thematic Analysis Results

E.1. The Twenty-Eight Codes and Six Themes Obtained from Interviews Conducted in the Khuean Ubolratana Subdistrict Area

No.	Theme	Coding	Key component 1	Key component 2
1.1	Unregistered residents	Commuter population (visitors and passersby)	source	
1.2		Unregistered population (out-of-the-area workers)		on-site waste management
1.3		Tourists		
2.1	Ineffective waste management processes	Waste quantity beyond the manageable capability		
2.2		Open dump and open burning practices	on-site waste management	waste disposal
2.3		Inadequate waste containers		
2.4		Lack of waste-segregated bins		
2.5		Inadequate room for storing waste		
2.6		Invasion of stray animals		
2.7		No collection service	waste collection	
2.8		Collection day frequency		
2.9		There is no proper waste disposal site in the community	waste disposal	
2.10		Limit waste capacity at community disposal site.		
2.11		Underperforming waste disposal infrastructure		
2.12		No provider of infectious waste service		
3.1	Civic waste management behavior and participation	Low public participation in the community waste separation process	on-site waste management	
3.2		Dumping of household waste in public open spaces		
3.3		Lack of community engagement program		
4.1	Public awareness and attitude	Did not acknowledge the importance		
4.2		Lack of waste management knowledge		
4.3		No integration of waste management in the school curriculum		
4.4		Outdated personal norm		
5.1	Lack of resource	Lack of budget	others	
5.2		Lack of human resource		

6.1	Bureaucratic constraints	Change of chief officer/policy direction too often		
6.2		Abided by national regulations and administrative rules		
6.3		Overlapping responsibility and function of LAOs		
6.4		Lack of cooperation from other organizations		

Table 5. The Codes and Themes Obtained from Interviews Conducted in the Khuean Ubolratana Subdistrict Area

E.2. The Bar Graphs of Thematic Coding Analysis

The bar graphs below depict the frequency of mentions for various topics, separated for the MUNI and SAO. Only codes mentioned more than three times are included.

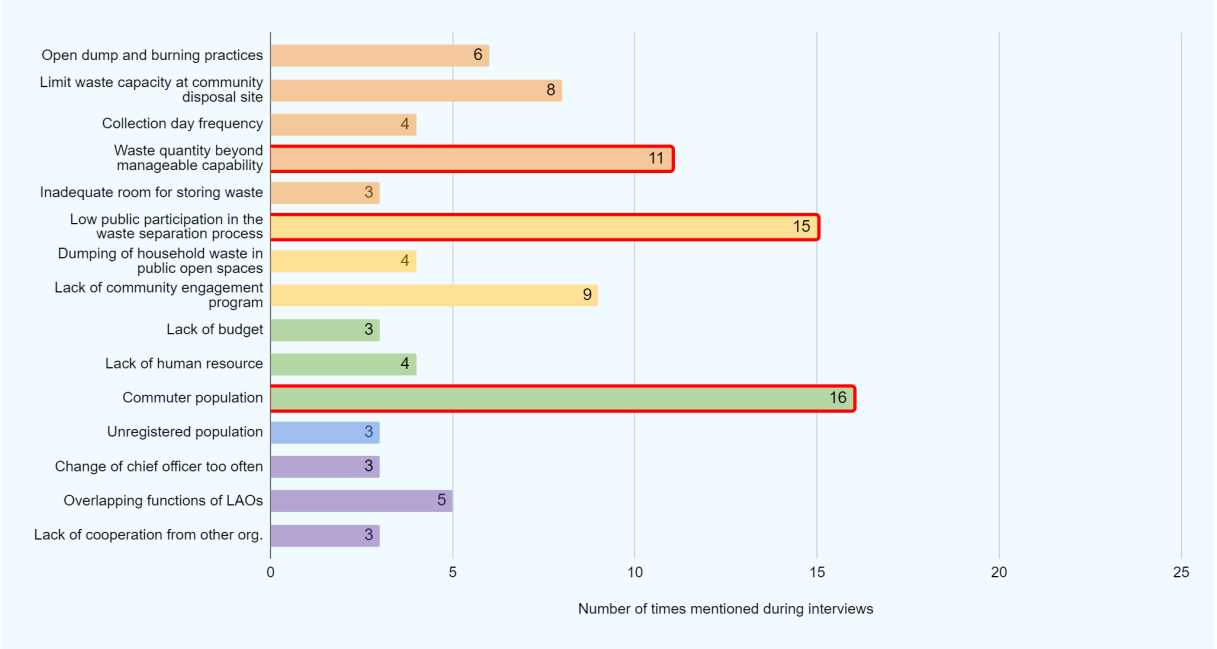

Figure 36. The Thematic Coding Analysis from the Interviews at MUNI

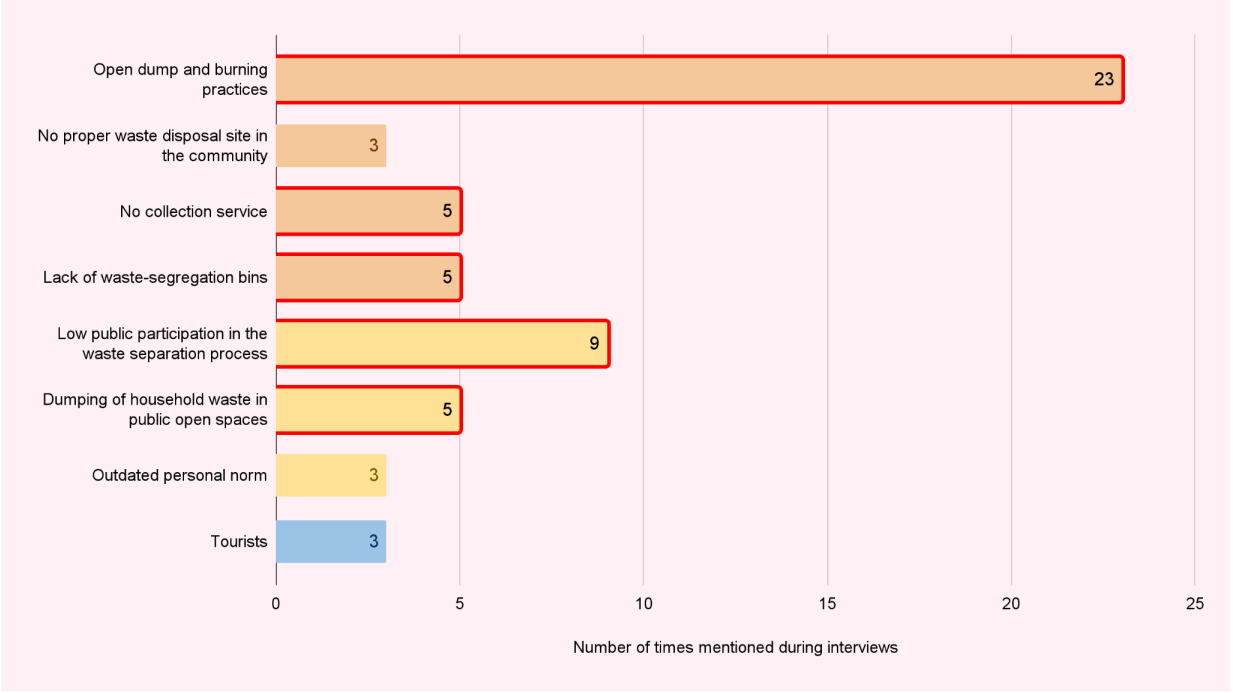

Figure 37. The Thematic Coding Analysis from the Interviews at SAO

Appendix F: The Criteria for the Effectiveness of the Key Components of the MSW Management System

Key components/colors				
1. Source	- High quantity of Waste - Have an insufficient waste management plan - Have waste from unforeseen sources	- High quantity of waste beyond manageable capability - Insufficient management plan	Normal quantity	- Normal quantity - Have a waste management plan
2. On-site waste management	Lack of waste management practices	Inefficient waste management efforts	Some efficient waste management efforts	Efficient Waste Management Practices
3. Waste collection	No waste collection	Waste collection on special events only	Inadequate scheduled waste collection	Good waste collection system
4. Waste transfer	Lack of waste transfer station, no further waste segregation	There is a waste collection station, no waste segregation	There is a waste collection station, some waste segregation	There is a waste collection station, thorough waste segregation
5. Waste disposal	- No proper waste disposal site - Practice open dumping and burning	- No proper waste disposal site - May use ineffective methods to dispose of waste	Proper waste disposal site presence but insufficient capacity, leading to leftover trash	Proper waste disposal site presence and enough capacity

Table 6. The Criteria for the Effectiveness of the Key Components of the MSW Management System

Appendix G: Organization with Good Waste Management Practice

G.1. Chulalongkorn University ZeroWaste (CUZeroWaste)

Chula Zero Waste is an organization that was initiated through collaboration between the Environmental Research Institute at Chulalongkorn University and the Physical Plant and Property Management Office at Chulalongkorn University. Its mission is to become a globally recognized university in sustainability, focusing on addressing environmental issues. The organization aims to achieve Net Zero Greenhouse Gas emissions by 2050. This goal involves promoting awareness of environmentally friendly lifestyles among faculty, staff, students, and Chulalongkorn University Demonstration School students. Additionally, it extends to the university's surrounding community.

G.2. Rung Aroon School

Rung Aroon School, catering to kindergarten through high school students, is located amidst the shade of large, lush trees and a shady forest garden. The school recognizes the value of environmental resources and integrates them into everyday life. In the past, the school needed a better waste management system, where wastes would be gathered in plastic bags and awaited collection by the truck collection service provided in the area. However, the irregularity of the truck collection services resulted in the accumulation of waste on the school premises, giving rise to unpleasant odors and environmental concerns.

Figure 38. The Zero Waste Project at Rung Aroon School

In response to the issue, Figure 35 above shows initiated efforts to identify the source of the odor and implement measures to mitigate its occurrence. The first step involved systematically sorting waste into designated garbage bins, prioritizing separating organic waste due to its propensity for decomposition. This marked the beginning of the Zero Waste Project within the Rung Aroon School community, including active participation from students, teachers, parents, officials, and other community members.

At present, Rung Aroon School has facilitated proper waste management for each different type of waste, as follows:

(1) Recyclable waste:

The waste is sorted based on the product's material to be disposed of. The common waste is plastic bottles and foams. This waste will eventually be sold to vendors, reused for arts and crafts, and companies to produce a new product. The school has a designated place to sort the different types of waste into labeled bins with an expert teacher, Khun Mon, who is passionate about waste, stationed at the waste sorting place. Students and teachers come to the waste sorting place with their waste that has been cleaned and dried, sorting them into the type of waste. When students are unsure about the types of waste, they will be assisted by an expert teacher who will help them learn simultaneously.

Figure 39. Waste Sorting Category at Roong Aroon School

As shown in Figure D, waste is sorted according to the type of material it is made of. Plastics are sorted based on the type of plastic: Low-Density Polyethylene (LDPE), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), etc. Glassware and metal cans are also sorted into the designated bins.

After the waste is sorted under Khun Mon's supervision, saleable waste will be collected by the person from the factory for further processing, such as melting or recycling. For instance, the plastic lids from plastic bottles can be recycled by melting them. Once melted, it will be molded into plastic coasters, display items, or baskets. Waste that cannot be sold, such as foams, will be separated into pieces, and the vendor from the market will come to pick them up for use.

(2) Organic waste:

The school has sorted its organic waste, starting from the kitchen area. For instance, the food waste is mango fruit. The different parts of the mango are separated into bins—the skin and the seed. This allows the person in charge of decomposing the food waste to use all the waste produced effectively.

Figure 40. The Before and After Decomposition of the Fruit Skins

a. Compost

The process involves layering various organic materials, including leaves, eggshells, banana shoots, and food waste, to promote the growth of beneficial microorganisms and maintain optimal conditions for decomposition.

It is essential to decompose food waste with leaves; thick leaves are avoided to allow air circulation. Food with oil content is not recommended. Then, cover the compost with wooden boards for a day to prevent odor, add water, and allow air entry. Beneficial microorganisms will decompose the materials, and adding dried cow feces as food for microorganisms will accelerate the process.

To accelerate microbial activity, increase protein-rich animal manure and avoid cooking enzymes. Wetting the leaves enhances microbial activity, and a thick solid base allows water drainage. An open-air system is better than a closed tank, allowing sunlight and airflow. Water flow and aeration are crucial factors for decomposition.

i. Earthworms

The food waste that has been decomposed over some time will then be mixed with the soil. Earthworms present in the soil will eat the decomposed food wastes. When incorporated into the soil, food wastes act as organic matter. As decomposers, earthworms eat these food scraps and convert them into nutrient castings. By adding vital nutrients and strengthening the soil's structure, these castings, also known as worm manure, increase the fertility of the soil. In exchange, soil enhanced with organic matter provides earthworms with a favorable habitat. Through the activities of earthworms, food scraps contribute to soil health through this harmonious circle of interdependence, producing a balanced and nutrient-rich ecosystem.

ii. Effective Microorganisms (EM) and SCOBY Fertilizers

The organic waste is treated using the microorganisms to be composted as bio-fertilizers. There is the EM fertilizer and the liquid fertilizer, which would be used for the school compound plants or sold to the locals around the area.

Figure 41. Effective Microorganisms (EM) and SCOBY Fertilizers

(3) Used water and wastewater:

A closed and open treatment pond is used to clean used water and wastewater from the school building and kitchen. High school students participate in this wastewater treatment project. It is utilized for plant irrigation before it clears up and flows back into the public canal.

This sorting involves people starting with students, parents, and people staying around Rung Aroon School. This engagement is mainly present in the sorting of recyclable items. Parents who have their children studying at the school can drop their trash in the school for sorting on Mondays to Wednesdays. This makes waste management more accessible to parents and their children, fostering a shared understanding of waste.