



Solid Waste Quantity, Composition and Characteristic, and Its Current Management at Elephant Study Center (Surin, Thailand)

Atitaya Salangam¹, Jaratsri Phimyon¹, Panchai Kessada², Pongthipun Phuengphai³, Chutima Thanomsit⁴, Tongsai Jammongkan⁵, Sampan Tongnunui⁶ and Amnuay Wattanakornsiri^{1*}

¹Program of Environmental Science, Faculty of Science and Technology, Surindra Rajabhat University, Surin, 32000, Thailand

²Program of Curriculum and Instruction, Faculty of Education, Surindra Rajabhat University, Surin, 32000, Thailand

³Program of Chemistry, Faculty of Science and Technology, Surindra Rajabhat University, Surin, 32000, Thailand

⁴Department of Fisheries, Faculty of Agriculture and Technology, Rajamangala University of Technology Isan Surin Campus, Surin, 32000, Thailand

⁵Department of Fundamental Science and Physical Education, Faculty of Science at Siracha, Kasetsart University, Chonburi, 20230, Thailand

⁶Division of Biological and Natural Resource Science (Conservation Biology Program), Mahidol University, Kanchanaburi Campus, Kanchanaburi, 71150, Thailand

* Corresponding author. E-mail address: amnuaywattanakornsiri@hotmail.co.th

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Abstract

The main aspects of solid waste management in an area are the quantities, compositions and characteristics, as well as its current management situations. Elephant Study Center (or Elephant Village), well known by Thais and foreigners, presently lacks of data on generated solid waste quantities, compositions and characteristics, including its management. This study investigated the quantities using purposive sampling of solid waste containers, the compositions according ASTM D 5231-92 standard, and some characteristics, i.e. bulk density, moisture content and total solid, using weighting and weight differences. In addition, the current solid waste management problems, community participation levels, and recommendations were studied by using questionnaire and interviews. The results found that the average amount of solid waste was 138.44±15.42 kg/d. The compositions were 17.50%, 47.20%, 30.17% and 5.13% of organic waste, general waste, recyclable waste and other wastes, respectively. Besides, the characteristics of bulk density, moisture content and total solid were 0.037±0.003 kg/l, 57.75±6.85% and 42.44±6.78%, respectively. For the results of current solid waste management, the highest problems were: lack of solid waste management system (4.27±1.16), disarranged disposal (3.78±1.26) and lack of solid waste separation system (3.40±1.34), respectively. The lowest community participation levels in solid waste management were: campaign in using cloth bags, food boxes and baskets for reducing plastic bags and plastic foam (1.82±0.85), problem and cause searching of solid waste management (1.90±0.77) and performance in solid waste management following hygiene or sanitary perspectives (1.91±0.80), respectively, with the overall at lowest level (2.09±0.20). Besides, there was no community participation in solid waste management from interviews. Therefore, community should participate in solid waste management following sanitary solid waste management principle for sustainable management.

Keywords: community participation, Elephant Study Center, solid waste composition

Introduction

Solid waste generated by human activities including agriculture, industry, commerce, household as well as tourism causes much environmental pollution. Currently, it is one of the most visible environmental problems in Thailand because its management is generally not effective owing to the lacks of budgets, knowledgeable personnel and appropriate technologies of local organizations (Wattanakornsiri, Jandaeng, Jammongkan, & Labkosa, 2014). They have normally been open-dumped and/or open-burned (Chiemchaisri, Juanga, &



Visnanathan, 2007). These improper disposals create environmental problems, i.e. leachate flooding, environmental deteriorating, disease spreading, global warming etc. Furthermore, a limitation of expensive and unavailable land for sanitary landfill, a public protest, a lack of discipline and an absence of public awareness and behavior in solid waste management is visibly exist (Chiemchasri et al, 2007)

Tourism is one of the growing industries in Thailand, which inevitably generates solid waste problem in many tourist spots. Thailand Tourism Standard, TTS 615: 2015, also defined in Element 4: Management and Other Facilities; specifically in Item 4: there must be solid waste management and waste treatment (Ministry of Tourism and Sports, 2015). Elephant Study Center called “Elephant Village”, where there is the highest number of domesticated elephants in the world (MThail, 2018; Dooasia, 2018), is well known for Thais and tourists all over the world. It is located in Tha Toom District, Surin Province (as illustrated in Figure 1), northeastern Thailand within geographical coordinates of 103° to 105° N latitude and 15° to 16° E longitude. Tourists inevitably cause an increase of solid waste in visiting areas including Elephant Study Center.



Figure 1 Surin Province, northeastern Thailand Source: Adjusted from Michael Holland (2018)

There were approximately 1,199,453 and 190,449 tourists visiting Surin Province and Elephant Study Center during January to April in 2016 and 2017, consecutively, mainly from United States of America, United Kingdom, Netherlands, Germany and France (Surin Office of Tourism and Sports, 2018). To my knowledge and literature reviews, there have been no data and information regarding solid waste quantities, compositions and characteristics as well as its management in Elephant Study Center. Besides, from preliminary investigation there were many problems, i.e. lack of solid waste separation system, air pollution from bad smell and open-burning, aesthetic problem, and lack of good solid waste management. In the present study, we investigated the solid waste quantities, compositions and some characteristics, together with its current management problems and public participation in Elephant Study Center. These data are the utmost to be used for solid waste management in Elephant Study Center.



Methods and Materials

This research was studied from July 2017 to March 2018. Data on solid waste quantities, compositions and characteristics were investigated by purposive sampling of solid waste containers from 3 sorting locations, i.e. elephants' show area, shops' area, Elephant Study Center Office area, covering the Elephant Study Center that there were 5 containers in each location, totally 15 containers. From investigation, there were totally 30 containers that there were 10 containers in each location in the Elephant Study Center. The sampling was carried out according to American Society for Testing and Materials (ASTM), ASTM D 5231-92 (ASTM, 2003). The duration of the quantity study, starting from December 2017 to January 2018 being in Thai winter season, was divided into two periods consisting of weekdays (Tuesdays and Thursdays as representative) and weekends (Saturdays as representative) totally three weeks continuously from 4.00 PM – 6.00 PM.

For compositions, we used the coning and quartering process (European Commission, 2004) with weighting and then mixing, coning and quartering, respectively. Samples were manually classified into four categories, i.e. organic waste, general waste, recyclable waste and other wastes according to their compositions. Then, each category was weighed and recorded in the data sheet. This research did not concern with elephant dung because when we preliminary investigated, there was the elephant dung approximately 699.45 kg/d, which was used as fertilizers for agriculture.

For characteristics, bulk density was studied using a 100 l container filled with solid waste, then raised it up about 30 cm and then fell it down on the floor three times; after that, it was weighed and calculated to the bulk density (kg/l). Besides, samples' moisture content (%) was studied from the weight difference after oven-dried at 105°C for 24 h (Jilani, 2007; Wattanakornsiri et al., 2014). Total solid (%), being the dried solid waste, was calculated from the difference of moisture content from 100%. All experiments were done with five replicates.

Data on current community participation in solid waste management was studied using questionnaire. Population totally 134 people consisting of two Elephant Study Center officers, 6 community leaders, 70 mahouts and 56 shopkeepers were randomized to be the sampling group according to the simple random sampling method of Yamane (1967) with the confidential value at 95%. The sampling group was 100 people. The questionnaire was separated into five sections, i.e. demographic information, knowledge assessment in solid waste, current solid waste management problems in the Elephant Study Center, and current community participation in solid waste management. The collected data were processed through Statistical Program for the Social Science (SPSS) for the values of percentage, average and standard deviation. Moreover, we interviewed 6 community leaders as key informants comprising 2 village headmen and 4 members of Sub-district Administration Organizations with the interviewing form.



Results

Solid waste composition, quantity and characteristic

The results found that solid waste was generated around 138.44 ± 15.42 kg/d as illustrated in Table 1. The amount of generated solid waste each day was multiplied by two because we purposively sampled 15 containers (100 l each) from totally 30 containers (100 l each) in the Elephant Study Center.

Table 1 Generated solid waste quantities and visitors' number at Elephant Study Center

| Days of Data Collection | Weight (kg/d) | Visitors (people) |
|-------------------------|--------------------|---------------------|
| Tuesdays | 128.66 ± 6.11 | 462.67 ± 102.62 |
| Thursdays | 130.66 ± 3.05 | 641.67 ± 105.46 |
| Saturdays | 156.00 ± 14.42 | 936.33 ± 78.26 |
| Total | 138.44 ± 15.42 | 680.22 ± 223.27 |

Solid waste compositions and quantities as illustrated in Table 2 were investigated and calculated from the generated solid waste quantities totally three weeks including Tuesdays, Thursdays and Saturdays. General waste was the highest proportion (47.20%) comprising plastic bags, cloth rags, wood scraps and foam fragments. Accordingly, recyclable waste proportion (30.17%) mainly included plastic water bottles and papers.

Table 2 Compositions, quantities and weight percentages of solid waste in Elephant Study Center

| Composition | Weight (kg/d) | Weight percentage (%) |
|--------------------|---------------|-----------------------|
| Organic waste | 109 | 17.50 |
| General waste | 294 | 47.20 |
| Recyclable waste | 188 | 30.17 |
| Other wastes | 32 | 5.13 |
| 138.44 ± 15.42 | 623 | 100 |

For solid waste characteristics, moisture content is one of the key parameters used to determine the possibility of solid waste treatment applications, e.g. animal husbandry, recycling, composting, incineration and/or landfill (Wattanakornsiri et al., 2014); additionally, bulk density was average at 0.037 ± 0.003 kg/l. Moisture content was average at $57.75 \pm 6.85\%$. Besides, total solid characteristic is used for determination of those of the applications too because we know about the amount of dried solid waste without moisture that total solid in this research was average at $42.44 \pm 6.78\%$.

Current status of solid waste management

The results from the questionnaire including demographic information, knowledge assessment in solid waste, solid waste problems in Elephant Study Center, solid waste management problems in Elephant Study Center, and current community participation in solid waste management are as the followings.

Concerning demographic information illustrated in Table 3, the most questionnaire respondents were as the followings: being male 58 people (58%), aged from 30 to 39 (39%), holding senior high school (58%), being temporary employee (33%), having five members in household (36%), and gaining income ranging from 5,001 to 10,000 Thai Baht per month (44%).

**Table 3** Demographic information of questionnaire respondents

| Demographic information | No. of respondents (people) | Percentage (%) |
|--|-----------------------------|----------------|
| Sex | | |
| - Male | 58 | 58 |
| - Female | 42 | 42 |
| Ages (years) | | |
| - 21-29 | 18 | 18 |
| - 30-39 | 39 | 39 |
| - 40-49 | 37 | 37 |
| - 50-59 | 4 | 4 |
| - More than 60 | 2 | 2 |
| Educational level | | |
| - Primary school | 33 | 33 |
| - Junior high school | 6 | 6 |
| - Senior high school | 58 | 58 |
| - Diploma or equivalent | 2 | 2 |
| - Bachelor degree | 1 | 1 |
| Occupation | | |
| - Student | 1 | 1 |
| - Government officer / National enterprise officer | 1 | 1 |
| - Temporary employee | 33 | 33 |
| - Vendor / Private business | 25 | 25 |
| - Agriculturalist | 40 | 40 |
| Members in household (People) | | |
| - 2 | 6 | 6 |
| - 3 | 9 | 9 |
| - 4 | 26 | 26 |
| - 5 | 36 | 36 |
| - More than 5 | 23 | 23 |
| Income (Thai Baht per month) | | |
| - Less than 3,000 | 2 | 2 |
| - 3,001-5,000 | 8 | 8 |
| - 5,001-10,000 | 44 | 44 |
| - 10,000-20,000 | 43 | 43 |
| - 20,000-30,000 | 2 | 2 |
| - More than 30,000 | 1 | 1 |

The results of knowledge assessment revealed that the correspondents at Elephant Study Center had the knowledge of solid waste and its management at 20%, 74% and 6% of low (0-4 scores for 20 respondents), medium (5-6 scores for 74 respondents) and high (7-8 scores for 6 respondents) levels, respectively. The knowledge questions (yes/ no) comprised four questions of solid waste concerning the meanings of solid waste, garbage, dried solid waste and hazardous waste, as well as those of its management regarding the solid waste recycling, disposal, solid waste container and solid waste separation.

The rating scales of this research were 1.00-1.80, 1.81-2.60, 2.61-3.40, 3.41-4.20 and 4.21-5.00 were lowest, low, medium, high and highest levels, respectively. The results of solid waste management



problems illustrated in Table 4 found that the overall correspondents' opinion level was medium level (2.88 ± 0.92). The highest problems were: lack of solid waste management system (4.27 ± 1.16), disarranged disposal (3.78 ± 1.26) and lack of solid waste separation system (3.40 ± 1.34), respectively; besides, the lowest was problem leachate (1.61 ± 0.76).

Table 4 Solid waste management problems in Elephant Study Center

| Solid waste problem | Average \pm S.D. | Correspondents' opinion level |
|--|--------------------|-------------------------------|
| 1. Lack of solid waste management system | 4.27 \pm 1.16 | Highest |
| 2. Inadequate quantity of officers taking responsibility to solid waste management | 3.22 \pm 0.98 | Medium |
| 3. Inadequate quantity of solid waste container | 3.56 \pm 1.05 | High |
| 4. Lack of solid waste separation system | 3.40 \pm 1.34 | Highest |
| 5. Disarranged disposal | 3.78 \pm 1.26 | Highest |
| 6. Having bad smell | 2.15 \pm 0.99 | Medium |
| 7. Public area disposal | 1.62 \pm 1.16 | Lowest |
| 8. Having aesthetic problem | 2.67 \pm 0.97 | Medium |
| 9. Drainage obstruction | 2.47 \pm 1.02 | Medium |
| 10. Leachate problem | 1.61 \pm 0.76 | Lowest |
| Overall | 2.88 \pm 0.92 | Medium |

The results of current community participation in solid waste management shown in Table 5 found that the overall correspondents' opinion level was lowest level (2.09 ± 0.20). The lowest levels in solid waste management were: campaign in using cloth bags, food boxes and baskets for reducing plastic bags and plastic foam (1.82 ± 0.85), problem and cause searching of solid waste management (1.90 ± 0.77) and performance in solid waste management following hygiene or sanitary perspectives (1.91 ± 0.80), respectively; moreover, the highest one was suggestion and recommendation in solid waste management at medium level (2.07 ± 0.93).

Table 5 Current community participation in solid waste management in Elephant Study Center

| Current community participation | Average \pm S.D. | Correspondents' opinion level |
|---|--------------------|-------------------------------|
| 1. Problem and cause searching of solid waste management | 1.90 \pm 0.77 | Lowest |
| 2. Public relation and persuasion in solid waste management | 1.92 \pm 0.83 | Low |
| 3. Planning in solid waste management | 1.94 \pm 0.86 | Lowest |
| 4. Operation following the plans | 1.88 \pm 0.83 | Lowest |
| 5. Evaluation of the plans | 1.95 \pm 0.84 | Lowest |
| 6. Planning of solid waste management in long-term | 1.95 \pm 0.84 | Lowest |
| 7. Suggestion and recommendation in solid waste problems | 2.07 \pm 0.93 | Medium |
| 8. Performance in solid waste management following hygiene or sanitary perspectives | 1.91 \pm 0.80 | Low |
| 9. Catching up news about solid waste problems | 2.19 \pm 1.09 | Lowest |
| 10. Performance following laws and regulations | 2.25 \pm 1.20 | Lowest |
| 11. Performance to be the model in solid waste management | 2.26 \pm 1.19 | Lowest |
| 12. Awareness creation for youths in importance of solid | 2.28 \pm 1.18 | Lowest |



Table 5 Cont.

| Current community participation | Average \pm S.D. | Correspondents' opinion level |
|--|--------------------|-------------------------------|
| waste problems and management | | |
| 13. Solid waste separation | 2.07 \pm 0.96 | Lowest |
| 14. Campaign in using cloth bags, food boxes and baskets for reducing plastic bags and plastic foam | 1.82 \pm 0.85 | Lowest |
| 15. Solid waste reduction by recycling | 2.01 \pm 1.00 | Lowest |
| 16. Garbage composting to fertilizer | 2.58 \pm 1.25 | Lowest |
| 17. Campaign in no public disposal of solid waste | 2.01 \pm 0.96 | Low |
| 18. Inform the officials of Elephant Study Center when solid waste containers being broken or inadequate | 2.24 \pm 1.16 | Lowest |
| 19. Activities' performance in solid waste campaign and gathering | 2.33 \pm 1.24 | Lowest |
| 20. Cooperation and supporting in solid waste management | 2.32 \pm 1.23 | Lowest |
| Overall | 2.09 \pm 0.20 | Lowest |

The results of interviews of 6 key informants were classified into five aspects and then concluded as the number of key informants answering similarity in each aspect as the followings. First, the aspects of solid waste problems and management were: lack of good solid waste management system (three informants), lack of relevant organizations in charge of solid waste management (two informants), lack of solid waste separation (two informants), lack of good or sanitary disposal (two informants) and inadequate quantity of solid waste container (one informant). Second, the aspects of solid waste management guidelines were: lack of solid waste management guidelines (6 informants), need for solid waste separation system (one informant), need for communal training in sanitary solid waste management (one informant), need for awareness creation in solid waste management (one informant) and need for relevant organizations in charge of solid waste management (one informant). Third, the aspects of community participation in solid waste management were: lack of community participation in solid waste management (6 informants), lack of public participations in community participation (one informant) and lack of community participation policy in solid waste management (one informant). Fourth, the aspects of desired solid waste management in the future were: desire to have good sanitary solid waste management (two informants), desire to have more officials being responsible for solid waste management (two informants), desire to have academic organizations to provide knowledge in solid waste management (one informant) and desire to have a recyclable waste bank for creating community awareness (one informant) Last, the other aspects were: desire to have good transportation system and adequate solid waste container (three informants), desire to have relevant organizations participating in solid waste management (two informants), desire to create community participation in solid waste management (one informant) and desire to persuade community to look after Elephant Study Center (one informant).

Discussion

The generated solid waste quantities on weekdays were lower than those on weekends; this is due to the numbers of visitors on weekends were higher than those on weekdays as illustrated in Table 1. For solid waste



composition as indicated in Table 2, general waste was the highest proportion (47.20%) mainly consisting of plastic bags, cloth rags, wood scraps and foam fragments, followed by recyclable waste (30.17%) comprising plastic bottles and papers. These are in accordance with Mateu-Sbert, Ricci-Cabello, Villalonga-Olives, and Cabeza-Irigoyen (2013) that tourist population causes an increase of general waste and recyclable waste in community. Moreover, bulk density of this study averaged at 0.037 ± 0.003 kg/l was lower than the work of Maneesai and Anurakpongsatorn (2011) in the range of 0.12 kg/l to 0.26 kg/l because lower bulk density generally shows that these solid waste fractions have more pore space and less compact (Zhao, Liu, & Duo, 2012). Moisture content was average at $57.75 \pm 6.85\%$ in accordance with the study of Wattanakornsiri et al. (2014) indicating the range of 45.26% to 65.39% because there was no waste separation system so the moisture could be transferred into each other composition. However, total solid averaged at $42.44 \pm 6.78\%$ was appropriately separated for other material applications and probably managed by incineration (Jankaew & Pamonpol, 2017). Then, Elephant Study Center should have a solid waste separation system.

Correspondents in the community of Elephant Study Center had knowledge of solid waste and its management at medium level so it needs to have training projects giving knowledge to them and support them to have more participation including creating awareness for solid waste management and environmental problems and conservations (Wattanakornsiri et al., 2014). Additionally, the highest solid waste management problems were: lack of solid waste management system, disarranged disposal and lack of solid waste separation system, respectively. The lowest community participation levels in solid waste management were: campaign in using cloth bags, food boxes and baskets for reducing plastic bags and plastic foam, problem and cause searching of solid waste management and performance in solid waste management following hygiene or sanitary perspectives, respectively. These results agreed with the interviews of key informants that solid waste management problems of Elephant Study Center were mainly: lack of solid waste management system, lack of sanitary disposal and lack of solid waste management separation system. And, perspectives of community participation of solid waste management of Elephant Study Center were mainly: lack of community participation in solid waste management and lack of community participation policy in solid waste management. Moreover, Chen, Ruijs, and Wesseler (2005) suggested that tourists or visitors do not normally feel responsible for solid waste problems with places where they visit; they are thought to have more free-rider behavior than community population. Therefore, public awareness campaigns created by local or relevant organizations help to minimize solid waste generation and increase its separation system (Deschenes & Chertow, 2004) and community must take the first responsibility on solid waste management. Besides, community must plan and create networks with other sectors (Khamwong & Talaluck, 2013). Hence for recommendations, community of Elephant Study Center should urgently have solid waste management system, sanitary disposal system and separation system, as wells as create community participation of solid waste management according to solid waste management principles for sustainable development.

Conclusion and Suggestions

This research found that the daily generation of solid waste in Elephant Study Center, Tha Tum District, Surin Province, northeastern Thailand was averaged at 138.44 ± 15.42 kg/d. The main compositions were general waste (47.20%) and recyclable waste (30.17%). There were currently many solid waste management



problems, i.e. lack of solid waste management system, disarranged disposal (3.78 ± 1.26), lack of solid waste separation system and so on. The community participation in solid waste management was in lowest level, i.e. campaign in using cloth bags, food boxes and baskets for reducing plastic bags and plastic foam, problem and cause searching of solid waste management, and performance in solid waste management following hygiene or sanitary perspectives. Moreover, community still lacked of enough knowledge in solid waste management. Hence, Elephant Study Center should have integrated solid waste management system and strategies, including training projects providing knowledge in solid waste, its management and environmental perspectives, as well as motivating community to participate for creating awareness in solid waste management. Suggestion for a further research topic should be an integrated solid waste management, strategy and application.

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