Evaluation of Greenhouse Gas Emission from Municipal Solid Waste Management and Leachate: A Case Study of Takhob Municipality, Thailand

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Abstract
The purposes of this research are to analyze the physical components of municipal solid waste and to analyze the greenhouse gas emission from municipal solid waste management and leachate in order to provide guidelines to reduce the greenhouse gas emission. The findings revealed that the municipal solid waste in Takhob Sub-district possessed the top 3 physical characteristics of the solid waste which were plastic, food waste and glass being 28.41%, 25.55% and 13.18%, respectively. The amount of greenhouse gas emission from the solid waste disposal system was 567.14 kilograms of carbon dioxide equivalent per ton. The results of greenhouse gas resulting from the leachate model in the landfill pond revealed that the greenhouse gas was composed of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) with the average density per month of 78.40, 0.33 and 0.03 mg/l, respectively. In addition, the average intensity of greenhouse gas was 96.06 mg CO_2eq /l. As for suggestions for solid waste disposal, the municipality should use technology to improve the disposal process by using incineration. However, the incinerator should be designed for characteristics of solid waste. According to the research, it was found that this method could reduce greenhouse gas by 208.95 kilograms of carbon dioxide equivalent per ton, and an integrated solid waste disposal method should also be used.
Keywords: Greenhouse Gas, Carbon Dioxide Equivalent, Municipal Solid Waste, Landfill, Solid Waste Management

Introduction
Solid waste problems are becoming more and more severe according to the growth of urban society and the changing lifestyles of the people. Causes of increase in solid waste are population growth increase in industrials manufacturing urbanization and modernization (Alam and Ahmade, 2013) When the situation of solid waste in Thailand is taken into consideration, it has been found that solid waste tends to increase every year with the slightly increasing proportion of solid waste that has been disposed of and utilized (Pollution Control Department, 2016), especially Nakhon Ratchasima, the province with the most areas of Thailand and the largest amount of solid waste in the northeast. Takhob Subdistrict

Municipality is a district in Pakthongchai District, Nakhon Ratchasima. It is located in the southwest of the province. Takhob Subdistrict Municipality is an area that tends to become more dense. It consisted of commercial communities, markets, industrial factories, gas stations, natural tourist attractions with more visitors, resulting in the increasing amount of solid waste. The social conditions and changing lifestyle make it convenient for people to have values and convenient behaviors to fulfil the needs of hectic lifestyle. As a result, there is an increase in solid waste resulting in the accumulation of solid waste in the area due to ineffective disposal which ultimately leads to environmental impacts. Takhob Subdistrict Municipality has 900 tons of collected solid waste per year and has a total of 2,100 tons of accumulated solid waste. The amounts of communal solid waste in Takhob Municipality during 2013-2017 are approximately 1,795 1,840 1,892 1,952 1,980 tons/year, respectively. (Takhob Subdistrict Municipality, 2017)

The impact of the increase in waste is that it cannot be gotten rid of completely and results in a large amount of accumulated solid waste. The release of gas and leachate away from the landfill boundaries and their release into the surrounding environment present serious environmental concerns at both existing and new facilities. Besides potential health hazards, these concerns include, and are not limited to, fires and explosions, vegetation damage, unpleasant odors, landfill settlement, ground water pollution, air pollution and global warming. (Mutasem, Angelos, & James, 1997) Therefore, it may result in economic losses and, ultimately, affect the society, especially the occurrence of global warming (Noinumsai, 2006). Each step of solid waste management emits greenhouse gas at different rates according to the methods. For example, solid waste disposal by landfill produces biological decomposition reaction in the landfill area. Solid waste and water in the landfill area are the raw materials, and the decomposition reaction produces gas and leachate which are the compositions of biogas or greenhouse gas. The gas is composed of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Greenhouse gases can absorb long-wave infrared radiation and exude heat energy at the earth's surface and atmosphere. When greenhouse gases are combined, the sun's rays which are supposed to be reflected back out of the atmosphere in the right amount are kept, resulting gradually rising temperature and leading to Global warming problem. Consequently, it affects humans and living things in the world severely, such as extreme weather, heat waves, floods, drought, rising sea levels, rising sea temperatures, severe tropical cyclones with increased and unusual frequency, and etc. Important elements of greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide. (N_2O), CFC (CFCs), Hydrofluorocarbon, Carbon (HFCs), Purfluro Carbon (PFCs) and Sulfur Hexafluoride (SF_6). (Thailand greenhouse gas management organization, 2018)

The municipal solid waste can be classified, according to its elements, into four types: degradable waste, recycling waste, hazardous waste and general waste (Council of Engineers, 2017). Each type of solid waste needs to be managed appropriately with steps that includes 1) reduction and segregation at the source, 2) collection, 3) storage, 4) transportation, 5) conversion and 6) disposal or elimination with the proper method according to the sanitary principles which involve Reduce and Reuse, Recycling, Energy Recovery and Final Disposal (Pollution Control Department, 2016).

In response to growing concerns about the threat of climate change, international action aimed at reducing greenhouse gas (GHG) emissions is accelerating and the solid waste management sector is expected to contribute. Previous laggards such as the United States of America (USA) have recently committed to a reduction of GHG emissions of 26-28% below 2005 levels by 2025, whilst China aims to peak carbon emissions by 2030 and obtain 20% of its energy from zero-carbon sources (Turner, Williams, & Kemp, 2014).

Therefore, the research on Evaluation of Greenhouse Gas Emission from Municipal Solid Waste Management and Leachate aims to analyze the physical elements of community solid waste, evaluate greenhouse gas emission from the municipal solid waste management and assess greenhouse gas emission from the leachate model in the landfill pond to provide a guideline for determining measures to reduce greenhouse gas emission which will result in the eco-friendly solid waste management according to the guidelines of the 12th National Economic and Social Development Plan in the 4th country development strategy in terms of environmentally friendly growth for sustainable development (Office of the National Economic and Social Development Board, 2017).

Methods

Analysis of Physical Components of Solid Waste

The analysis of physical components of solid waste was carried out by collecting samples from the solid waste disposal at Takhob Subdistrict Municipality. The samples were collected 12 times with 4 repeated collections. The percentage of solid waste components data was collected in year 2018. The Viriya (2014) methodology was used for analysis of physical components of solid waste. This methodology is simple and straightforward. The analysis of physical components of solid waste started from sampling the solid waste from the containers and mixing them to obtain the amount around 1-2 cubic meters. The large solid waste was cut into smaller size, and the density value was determined. The solid waste was then mixed together and then quartered. Two piles of solid waste on the opposite side were mixed, and the rest was disposed of. The selected piles of solid waste were mixed and quartered. Two piles of solid waste were selected from the other side. The step was repeated until the solid waste of 50 liters was obtained. The physical components of solid waste were separated. Solid waste components were calculated as percent and classified as food waste, paper, plastic, rubber, leather, cloth, glass, wood, metal, stone and tiles, hazardous waste and others.

Route Survey and Types of Solid Waste Collection Vehicle

The survey on the routes in Takhob Subdistrict Mulnicipality was conducted to identify the distance and fuel use, classified by types of vehicles.

Solid Waste Disposal Process Survey

This is a survey of the community solid waste disposal process of Takhob Subdistrict Municipality to determine how solid waste was disposed of, starting from the collection, transportation to the disposal source, disposal, amount of electricity generated in every activity and amount of fuel used in landfill. The data were used to calculate greenhouse gas emission. Landfill is the only type solid waste disposal of Takhob Subdistrict Municipality.

Assessment of Greenhouse Gas Emission from Municipal Solid Waste Collection and Disposal

This is a program to calculate the amount of greenhouse gas emission from solid waste management by using life cycle assessment methods under the project of measurement, reporting and verification for low-carbon development in Asia developed by Japan. The version 2 of the program to calculate the amount of greenhouse gas emission from solid waste management activities, developed by the Institute for Global Environmental Strategies (IGES), can be used to calculate the amount of greenhouse gas emission from both solid waste management methods and integrated solid waste management system. The program uses the life cycle approach (LCA) which allows users to calculate the amount of direct greenhouse gas emission (direct emission), the amount of greenhouse gas emission reduction, and the net amount of greenhouse gas for each method. Users can use this program to calculate the value in countries in the Asia Pacific region by selecting or entering specific values of the country based on the principle of calculating greenhouse gas emission from solid waste management and information as specified in the 2006 IPCC Guidelines for

National Greenhouse Gas Inventories, Volume 5 Waste (IPCC, 2006), prepared by the Intergovernmental Committee on Change (IPCC). Thailand must use such information to prepare the greenhouse gas statement to present to the Secretariat of the United Nations Convention on Climate Change.

The reason for choosing this program to calculate greenhouse gas emission is that this program has been developed for local administrative organizations for sustainable solid waste disposal. The program is based on the IPCC 2006 calculation formula which can calculate greenhouse gas emission from current solid waste disposal activities and predict the emission in the future. It will help local administrative organizations to plan solid waste disposal to reduce greenhouse gas and effects from climate change more effectively.

Assessment of Greenhouse Gas Emission from the Leachate Model in the Landfill Pond

This is a greenhouse gas emission model generated from residual waste and leachate from landfill. A plastic tank of 1 meter in width, 1.2 meters in length and 1.6 meters in height was used, and a PVC pipe was connected to simulate solid waste landfill to be as deep as the depth of Takhob Municipality waste pond, which is 2.5 meters in depth. The reason for choosing this model to calculate greenhouse gas emission is that this model simulates the landfill pond in 1 unit volume in order to identify the concentration of greenhouse gas. The samples had been collected for a period of 30 days both in the morning and in the afternoon. In this research, data were collected in the summer 2018, since the temperature, humidity and airless condition affect biological decomposition. So to speak, high temperatures result in more microorganisms and gas emission. For sampling and analyzing greenhouse gas emission, it started from putting the solid waste taken from the municipal waste dump in Takhob District in the model. Then, the equipment used to measure greenhouse gas emission was installed at the crater of the model with the FTIR gas analyzer equipment (Gasmet) Model DX4040 as shown in Figure 1.

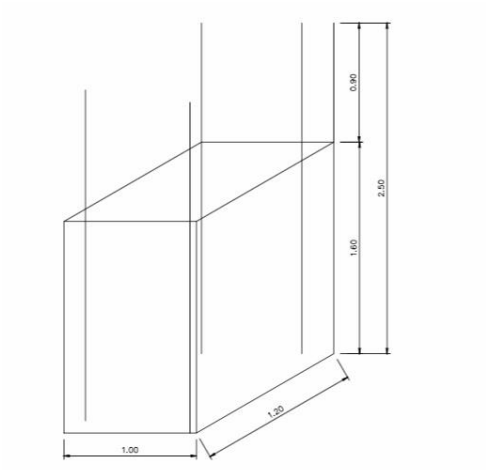

Figure 1. Model of Greenhouse Gas Emission from Residual Waste and Leachate

Results

The percentage of solid waste component data, Route Survey, Types of Solid Waste Collection, Vehicle Solid Waste Disposal Process Survey and Assessment of Greenhouse Gas Emission from the Leachate Model data was collected in year 2018.

The results indicated that the municipal solid waste in Takhob Subdistrict Municipality possessed 3 physical components: plastic, food waste and glass, which are 28.41%, 25.55% and 13.18%, respectively. The solid waste composition in each season had no significant statistical difference ($p > 0.05$). Details are shown in Figure 2.

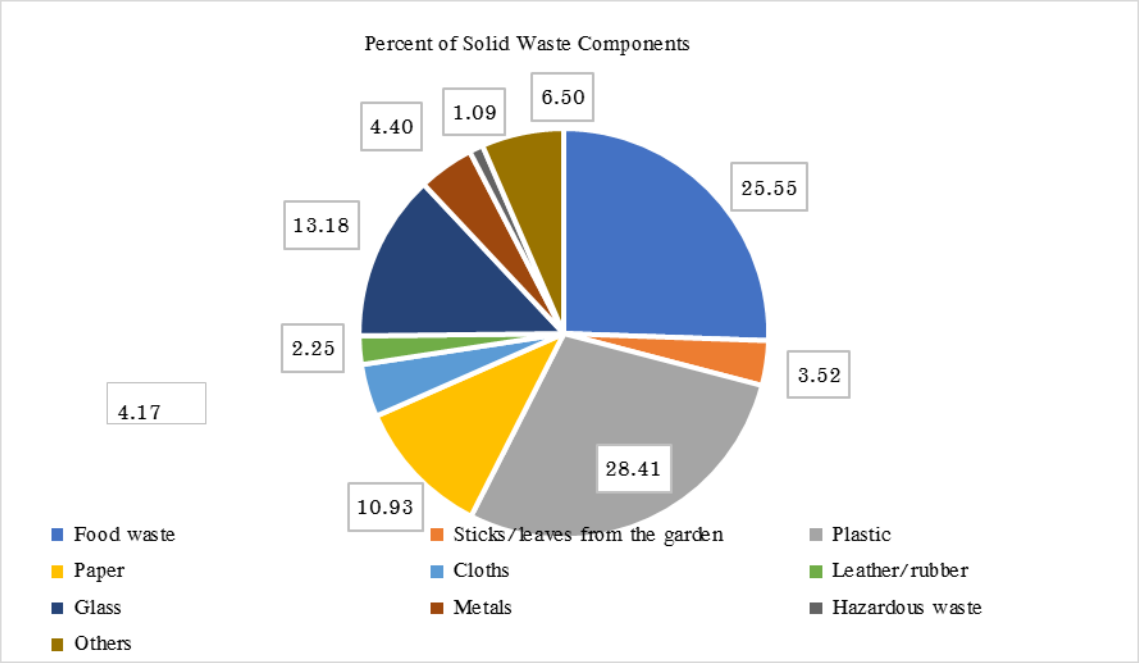

Figure 2. Percentage of Solid Waste Components

During the collection and transportation of the solid waste in Takhob Subdistrict Municipality, 3 small pick-up trucks were used to collect solid waste, which took off from Takhob Subdistrict Municipality Office and terminated at the garbage pond to collect solid waste from the bins in the responsible areas in Takhob Subdistrict Municipality at various points along the rural road. There are 3 garbage trucks in the municipality, and there are 3 routes for solid waste collection. Each truck runs on each route. After collecting solid waste from various points, all solid waste collected would be disposed of by using only the solid waste disposal system in which solid waste was poured into the landfill from time to time at Takhob Subdistrict Municipality solid waste disposal site.Landfill were the common practice for Municipality Solid Waste disposal all over the world. (Magda, El-Salam., & Gaber, 2014) There was neither sorting of solid waste before being discarded nor using the sorting bins. Landfill is no electricity. The details on the type of 3 cars used to collect solid waste are shown in Table 1 and the map of solid waste collection routes are shown in Figure 3 below.

Table 1 Details of 3 Cars Used to Collect Solid Waste

Type of Vehicle Engine	**Width of Vehicle (m.)**	**With of Container (m.)**	**Height of Container (m.)**	**Volume (Cubic m.)**	**Type of Fuel**	**Distance of Collection (km.)**	**Fuel Used during Transportation (liter/month)**	**Amount of Waste Transported (ton/mount)**
709 CC Engine	1.70	3.00	1.00	5.10	Diesel	14.5	96	28.25
709 CC Engine	1.60	2.80	1.00	4.48	Diesel	16	96	21.30
2,494 CC Engine	1.70	2.30	1.00	3.91	Diesel	9.5	96	16.86
Total							**288**	**66.41**

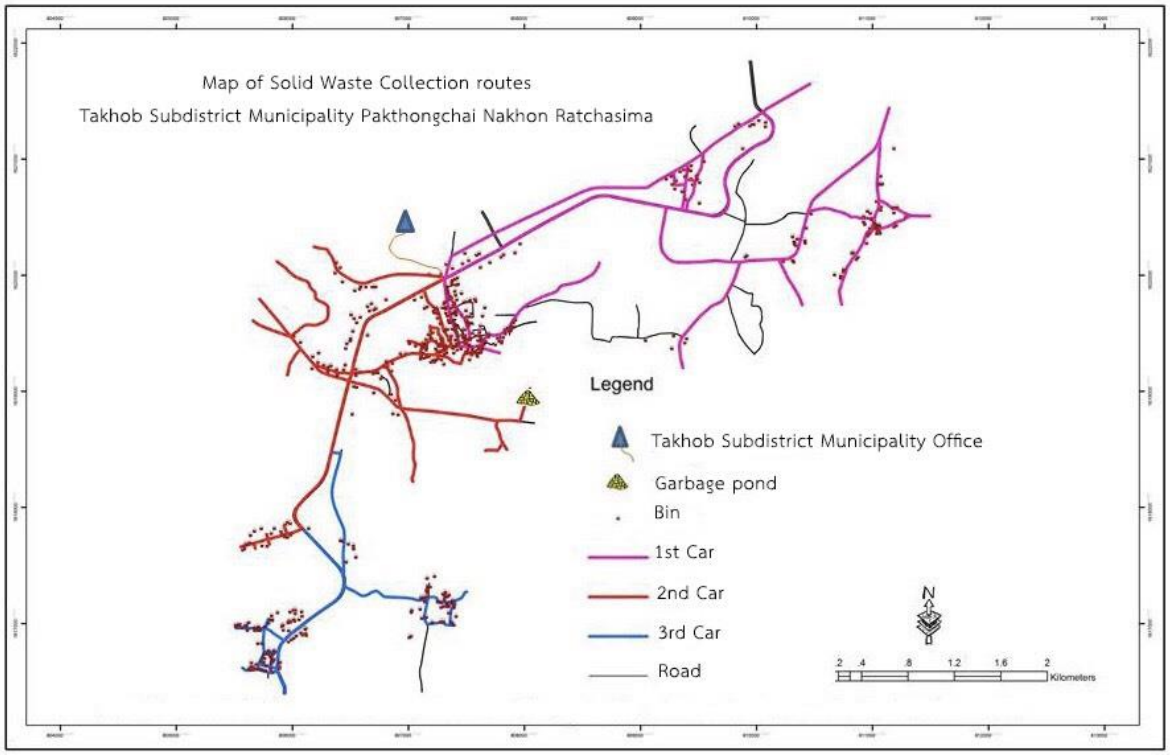

Figure 3 The map of solid waste collection routes

In terms of greenhouse gas emission from waste management of Takhob Municipality, it was found that the total amount of greenhouse gas emission from waste management system was 567.14 kilograms of carbon dioxide, which is equivalent to the average greenhouse gas emission of 56.32 tons of carbon dioxide equivalent per month. Considering each activity, it was found that the landfill process emitted the highest amount of greenhouse gas, accounting for 98 percent of the amount of greenhouse gas from the municipal solid waste management of Takhob Municipality. The amount of greenhouse gas from the landfill was equivalent to 554.46 kilograms of carbon dioxide equivalent per ton of solid waste. Two percent of the greenhouse gas came from the transportation activity which was 11.69 kilograms of carbon dioxide equivalent per ton of solid waste.

In terms of greenhouse gas emission from the leachate model in the landfill pond, it was found that the greenhouse gas in this research consisted of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) with the average concentration of 78.40, 0.33 and 0.03 mg/ l, respectively. Seven types of greenhouse gas consisted of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorescence Carbon (HFCs), Perfluorocarbon (PFCs), Sulfur Hexafluoride (SF_6) and Nitrogen Fluoride (NF_3). These findings are in line with the research results of Nopparit Sutthasil (2010) who found only 3 types of greenhouse gas from the study on Comparison of Leachate Properties and Greenhouse Gas Emissions from Anaerobic and Semi-Anaerobic Landfills. In his study, he found that the main components of biogas generated in the landfills were methane, carbon dioxide and nitrous oxide. Like Chatrapa Suethep (2014) who studied the influence of aeration on greenhouse gas emission from municipal solid waste landfills, she found that greenhouse gas generated in the solid waste landfill model consisted of carbon dioxide, methane and nitrous oxide. In addition, Siam Yimsiri (2014) who studied the amount of greenhouse gas emission from the landfills in Saen Suk Municipality found that greenhouse gas generated in the waste management process and the waste disposal process was the cause of global warming, and it consisted of 3 gases: carbon dioxide, methane and nitrous oxide, respectively. Moreover,

Onanong Bua-aaj and Pornpan Sakunku (2015), who studied the assessment of methane emission by Default, First Order Decay Method and LandGEM program from a controlled solid waste disposal facility: a case study of Nakhon Phanom Municipality, Nakhon Phanom Province, found that greenhouse gas generated in the solid waste landfill model consisted of carbon dioxide, methane and nitrous oxide as well. Furthermore, research showed that the average greenhouse gas concentration was 96.06.mg CO2eq/l. The leachate model collects data for 1 month. It collects data every day after 1 month, and the amount of greenhouse gas emission is stable and tends to decrease, which indicates that it is in the stationary state. The details are shown in Table 2.

Table 2 Concentration of All Greenhouse Gases

Date	Concentration of Greenhouse Gas						Concentration of Greenhouse Gas (mg CO_2eq/l)
	Carbon dioxide (CO_2) (ppm)	Carbon dioxide (CO_2) (mg/l)	Methane (CH_4) (ppm)	Methane (CH_4) (mg/l)	Nitrous Oxide (N_2O) (ppm)	Nitrous Oxide (N_2O) (mg/l)	
1	12,823.31	23.08	17.62	0.01	2.78	0.01	24.86
2	67,296.26	121.11	135.69	0.09	2.88	0.01	124.87
3	23,306.97	41.94	100.76	0.07	1.46	0.00	44.48
4	45,007.71	81.00	65.83	0.04	3.03	0.01	83.70
5	48,910.42	88.02	326.26	0.21	7.14	0.01	97.19
6	53,600.03	96.46	41.20	0.03	1.77	0.00	98.08
7	14,299.82	25.73	72.26	0.05	2.35	0.00	28.18
8	17,927.47	32.26	147.76	0.10	2.65	0.00	36.10
9	4,067.49	7.32	32.03	0.02	1.49	0.00	8.64
10	14,373.25	25.87	120.60	0.08	3.05	0.01	29.48
11	21,829.04	39.28	266.96	0.17	4.02	0.01	45.81
12	18,881.73	33.98	312.19	0.20	4.05	0.01	41.26
13	65,399.28	117.69	837.27	0.55	15.88	0.03	139.91
14	52,975.76	95.33	512.91	0.34	12.70	0.02	110.54
15	74,841.23	134.68	805.45	0.53	16.47	0.03	156.69
16	45,257.08	81.44	300.34	0.20	13.28	0.02	93.48
17	23,393.48	42.10	448.49	0.29	12.62	0.02	56.20
18	25,340.05	45.60	586.09	0.38	18.28	0.03	64.99
19	42,142.00	75.84	760.45	0.50	25.05	0.05	101.72
20	37,175.27	66.90	812.92	0.53	24.89	0.04	93.55
21	34,393.20	61.89	1,101.89	0.72	22.43	0.04	91.95
22	17,459.36	31.42	429.80	0.28	14.98	0.03	46.48
23	50,996.53	91.77	749.20	0.49	41.29	0.07	126.17
24	58,091.05	104.54	683.73	0.45	37.89	0.07	136.05
25	51,536.00	92.74	796.85	0.52	32.23	0.06	123.06
26	49,628.25	89.31	360.51	0.24	24.43	0.04	108.31
27	56,444.07	101.58	1,014.26	0.66	30.02	0.05	134.27
28	168,915.49	303.98	1,281.77	0.84	62.90	0.11	358.68
29	52,574.38	94.61	1,314.51	0.86	22.08	0.04	127.96
30	58,112.66	104.58	913.82	0.60	55.25	0.10	149.16
Average	**43,566.62**	**78.40**	**511.65**	**0.33**	**17.31**	**0.03**	**96.06**

Discussion and Conclusion

In addition, when analyzing the results of the percentage of solid waste, it was found that the first three solid waste components found in the Takhob Subdistrict Municipality were plastic, food waste and glass, accounting for 28.41%, 25.55% and 13.18% respectively. These findings corresponds to Maneesai (2011) who studied the analysis of quantity and components of solid waste to provide guidelines for solid waste management in Jed Sao Noi Waterfall National Park in Saraburi. She found that the top 3 solid waste components found in the Jed Sao Noi Waterfall area included food waste (53.21%), plastic (25.27%) and glass (14.07%). The findings are in line with Noinumsai & Phothikhanit (1998) who studied the current conditions of solid waste disposal and the effects of landfill waste disposal in Nakhon Ratchasima Municipality. They found that the top 3 physical components of solid waste in Nakhon Ratchasima Municipality were food waste, paper and plastic, accounting for 38.27%, 15.98% and 15.12%, respectively. They are the same components as those found in Takhob Subdistrict Municipality. In addition, Yimsiri (2014) studied the amount of greenhouse gas emission from landfill ponds in Saen Suk Municipality and found that the top 5 solid waste components were food waste, plastic, paper, boxes, crates and glass, accounting for 38.13%, 28.45%, 11.75%, 4.77% and 2.3%, respectively. Moreover, Srimanta (2012) studied the assessment of reduced greenhouse gas emission from the improvement of solid waste management in Khon Kaen University. According to her study, when comparing greenhouse gas emission by landfill waste disposal in Case 1 and the waste disposal involving waste sorting for recycling, making fertilizer and landfill in Case 2 in municipal waste disposal activities which included transportation, waste sorting, recycling, organic fertilizer fermentation and landfill disposal alone, Case 1 released greenhouse gas consisting of methane and carbon dioxide of 3,349.03 tons of carbon dioxide equivalent per month, accounting for 100 percent. However, the waste disposal by waste sorting for recycling and making fertilizer along with landfill in Case 2 produced greenhouse gas consisting of methane and carbon dioxide in the amount of 3,213.55 tons of carbon dioxide equivalent per month accounting for 95.96 percent. When the municipality held activities for people to sort waste and make aerated organic fertilizer, the greenhouse gas emission was reduced by 135.48 tons of carbon dioxide equivalent per month, accounting for 4.04 percent, compared to the total emission of greenhouse gas from landfills. For this reason, solid waste should be reduced at the source by campaigning waste sorting and proper waste disposal. Organic solid waste should be utilized by anaerobic fermentation, and methane gas should be stored for utilization. Garbage trucks should have containers so that they can carry more volumes or change how they collect solid waste. According to the study, the physical characteristics of solid waste are in accordance with those of other research works in several areas in that consumer products and consumer behaviors in such areas are similar. Therefore, the physical characteristics of solid waste have no significant difference.

When analyzing solid waste data in Takhob Municipality Analyzed in the IPCC model to determine the amount of greenhouse gas emission as a result of solid waste elements, it was found that the highest emission of greenhouse gases from paper landfill was 223.83 carbon dioxide equivalent per ton per month, followed by cloths, sticks/leaves and food waste which emitted greenhouse gases 134.32, 112.05 and 84.05 carbon dioxide equivalent per ton per month, respectively. Plastic, leather/rubber, glass, metal, hazardous waste and other waste emitted greenhouse gases 0.05 carbon dioxide equivalent per ton per month.

According to the research, it was found that landfill should be reduced as it emits the most greenhouse gases. The amount of greenhouse gas produced from landfill was equal to 555.46 kilograms of carbon dioxide equivalent per ton. According to the analysis in the model based on the calculation of the amount of greenhouse gas emission from solid waste management and information specified in the IPCC to find a solid waste management model that could

reduce greenhouse gas emission, it was found that if the waste was disposed of by composting, turning it into biogas, using Mechanical Biological Treatment (MBT), recycling and incineration, the greenhouse gases could be reduced by 40.15, 47.96, 320.19, 9.26 and 208.95 kg of carbon dioxide equivalent per ton, respectively. In addition, an integrated waste disposal method should also be used by campaigning for people to participate in reducing solid waste and separating waste properly in order to reuse, recycle and dispose of the waste in the most effective way, as well as minimizing the amount of solid waste that needs to go through the waste management processes. A good waste separation system will result in an effective solid waste management. In the process of collecting and transporting solid waste, the carbon dioxide emissions can be reduced by using fossil fuel and switching to fossil fuel that reduces greenhouse gas emission, such as natural gas and biodiesel oil. In addition, the number of trips and distance of garbage collection should be reduced. For example, the municipality should use the truck that has a solid waste compression system to collect solid waste and reduce the number of trips. In case the collection spot is far from the disposal spot, a waste transfer station should be established.

When considering the appropriate factors for waste disposal by incineration, it was found that the factors for choosing an incinerator were the characteristics of solid waste which are highly flammable with the humidity level below 40-50% and the heat value obtained from combustion above 800 kcal/kg. According to the research on the physical and chemical elements, it was found that the municipality could use the incineration method with the incinerator, and it could dispose of a variety types of solid waste. In addition, because there is no industrial sector in the municipality area of which the energy generated from plastic fuel (RDF) with high energy value obtained from the waste treatment process using MBT method can be used to replace fossil fuel in the industrial sector, the municipality should use the incineration technology to manage the remaining solid waste. However, the incinerator should designed to suit the characteristics of solid waste for effective incineration. At present, Takhob Municipality has no wet and dry solid waste separation system, the solid waste is of high humidity and results in low heat.

It can be concluded that solid waste problems are major problems in Thailand, and Takhob Subdistrict Municipality has had residual waste problems. After studying the physical characteristics of solid waste, it was that the top three physical components of solid waste were plastic, food waste and glass, accounting for 28.41%, 25.55% and 13.18%, respectively. The amount of greenhouse gas emission from the collection and disposal of municipal solid waste was 567.14 kilograms of carbon dioxide equivalent per ton of solid waste. The results of the greenhouse gas from the leachate model in the landfill pond showed that the greenhouse gas generated consisted of carbon dioxide, methane and nitrous oxide with the average concentration of 78.40, 0.33 and 0.03 mg/l, respectively, and the average greenhouse gas concentration of 96.06 mg CO_2eq/l. As for suggestion Takhob municipality should use technology to improve the disposal process by using incineration. However, the incinerator should be designed for characteristics of solid waste and should also be used by campaigning for people to participate in reducing solid waste and separating waste properly in order to reuse, recycle and dispose of the waste in the most effective way, as well as minimizing the amount of solid waste that needs to go through the waste management processes. Finally, it can reduce greenhouse gas emission from the municipal solid waste management process in Takhob District, Pakthong Chai District, Nakhon Ratchasima, which will lead to sustainable and environmentally friendly solid waste management practices.

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