THE COMPARATIVE STUDY ON GREENHOUSE GAS EMISSION FROM LIVESTOCK FARMING WITH DIFFERENT WASTEWATER TREATMENTS IN CHACHOENGSAO PROVINCE, THAILAND

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ABTRACT

This study focused on the emission of greenhouse gases (GHGs) from livestock farming in Chachoengsao Province, Thailand. Two objectives were (1) to investigate the concentration of CO_2 and CH_4 emitted from wastewater systems in swine farms, (2) to compare the concentration of these greenhouse gases emitted from different wastewater treatments of swine farms which were anaerobic filter tank system and stabilization pond system, and (3) to indicate the relationship between the concentration of CO_2 and CH_4 emitted from wastewater systems in swine farms. A number of twelve swine farms were selected as the sample of this study in which six of them represented the farms having anaerobic filter tank system and the rest represented the farms with stabilization pond system as their wastewater treatment plants. Statistical methods used to analyze data were mean ($\overline{X}$), minimum, maximum, independent – samples test (t – Test) and Pearson correlation coefficient (r) at the significant level of 95%. Results of the study showed that (1) the concentration of CO_2 emitted from anaerobic filter tank and stabilization pond system varied widely between 57.0 to 5,545.0 and 2,755.0 to 28,662.0 ppm., respectively. In the same manner, the concentration of CH_4 also varied widely between 11.3 to 5,924.0 from anaerobic filter tank system and 1,500.0 to 15,620.2 ppm. from stabilization pond system; (2) the emission of CO_2 and CH_4 from anaerobic filter tank system and stabilization pond system were statistically different at the significant level of .01 [Sig. = .007 and .009 < α (.01)]. Besides, the study indicated that relationship between the concentration of CO_2 and CH_4 was at a very high level with the correlation coefficient (r) of 0.925. It means that the concentration of these two greenhouse gases will change in the same direction. That is, if the concentration of CO_2 increase, the concentration of CH_4 will also increase, and vice versa.

Keywords: greenhouse gases, carbon dioxide (CO_2), methane (CH_4), livestock farming, anaerobic filter tank, stabilization pond.

INTRODUCTION

It is apparent that the problem of climate change has occurred very widely in every part of the world during the past decade. This phenomenon can be described by the reason of "global warming" and "greenhouse effect" that are related to the increase of greenhouse gases covering the atmosphere especially in the ozone layer. The important causes of this greenhouse effect come from human activities in different sectors such as agriculture and livestock farming, production of goods and services in industrial sector, development of mass transportation, deforestation and dispose of solid wastes. It was reported that cultivation of main crops led to the release of greenhouse gases to the atmosphere about 24% while livestock farming produced not less than 18% of the whole amount of greenhouse gases caused by agricultural sector. [1] In Thailand, however, Ministry of Natural resources and Environments stated that, in the year 2005, activities from energy sector became the main source to produce the highest amount of greenhouse gases or about 56.1% and followed by agriculture, waste generation, land use change and deforestation, and industry at 24.1, 7.8, 6.6 and 5.4%, respectively. [2].

The other important source of greenhouse gases emitted to the atmosphere is from biodegradable reaction of wastewater in swine farm under anaerobic condition. It was reported that swine farm industry in Thailand generally used 10 to 20 liters of water per head of swine per day for daily cleaning. [3] These amount of water were then collected to wastewater system in each swine farm such as anaerobic filter tank and stabilization pond. A study by Pollution Control Department in 1999 showed that wastewater from the small size of swine farms

contained organic wastes in the form of BOD at 1,500 mg/L by average whereas those from the medium and large sizes of swine farms contained organic wastes in the form of BOD at the average of 2,500 to 3,000 mg/L. [4]

It is anticipated that wastewater from swine farms in Thailand will create environmental pollution more seriously. This is because the population of swine in the country tends to increase every year. For example, there were approximately 9.5 million of swine population in 2014 [5]; then, the population increased up to 10.19 million in 2017 [6]. Therefore, relevant government sectors need to pay more attention to control wastewater pollution in swine farms so that the emission of greenhouse gases from this source would be mitigated.

OBJECTIVES

Objectives of the comparative study on greenhouse gas emission from livestock farming with different wastewater treatments in Chacoengsao province, Thailand, were as follows: -

1. to investigate the concentration of CO_2 and CH_4 emitted from wastewater systems in swine farms,
2. to compare the concentration of CO_2 and CH_4 emitted from different wastewater treatments of the swine farms, and
3. to indicate the relationship between the concentration of CO_2 and CH_4 emitted from wastewater systems in swine farms.

METHODOLOGY

The study method of this research can be described according to the following detail: -

1. Field survey

In this research, a number of twelve swine farms in Maung district of Chacoengsao province having wastewater treatment system were selected as the sample by purposive sampling technique. This sample was divided into 2 groups which consisted of 1) six swine farms with anaerobic filter tank system by the capacity of 5 – 10 m^3/day or the number of 250 – 500 swine population, and 2) six swine farms with stabilization pond system by the capacity of 10 – 30 m^3/day or the number of 500 – 2,000 swine population. In this case, they were the representative for the total amount of 104 swine farms located in the study area.

2. *Data collection*

The concentration of greenhouse gases emission, CO_2 and CH_4, from wastewater treatment systems of both groups of swine farm mentioned above were collected by the following processes: -

2.1 Greenhouse gas concentration in anaerobic filter tank system

CO_2 and CH_4 emission from anaerobic filter tank system of six swine farms in the study area were measured by using 20 m^3 of air bag and pump connected with ventilation pipe on the top of each anaerobic filter tank of those farms. The collection of air samples were taken two times during a day which were one hour from 09.00 to 10.00 am. in the morning and another one hour from 15.00 to 16.00 pm. in the afternoon. After that, gas detector named "MIRAN SapphIRE XL" was used to analyze the concentration of both CO_2 and CH_4 in each tank of those swine farms.

2.2 Greenhouse gas concentration in stabilization pond system

CO_2 and CH_4 emission from stabilization pond system of six swine farms in the study area were measured by using flux chamber at the middle point of each stabilization pond. The collection of air samples were also taken two times during a day which were one hour from 09.00 to 10.00 am. in the morning and another one hour from 15.00 to 16.00 pm. in the afternoon. After that, gas detector named "MIRAN SapphIRE XL" was used to analyze the concentration of both CO_2 and CH_4 in each stabilization pond of those swine farms.

3. Statistical methods

3.1 descriptive statistics

The descriptive statistics used in this research were mean ($\overline{X}$ **)**, minimum and maximum of CO_2 and CH_4 concentration emitted from both anaerobic filter tank and stabilization pond in each hour of the measurement taken in the morning and in the afternoon during a day of collection.

3.2 Inferential statistics

The inferential statistics used in this research were independent – samples test (t – Test) and Pearson correlation coefficient (r) at the significant level of 95%. Independent – samples test was used in order

to describe whether the concentration of CO_2 and CH_4 emitted from anaerobic filter tank system and stabilization pond system of swine farms were different or not. In this case, the hypotheses were as follow: -

H_0: GHG concentration emitted from anaerobic filter tank system and stabilization pond system in swine farms were not different.

H_1: GHG concentration emitted from anaerobic filter tank system and stabilization pond system in swine farms were different.

In addition to independent – samples test, Pearson correlation coefficient (r) was used to indicate whether the concentration of CO_2 and CH_4 released from anaerobic filter tank system and stabilization pond system of swine farms were related to each other or not. In this case, the hypotheses were as follow: -

H_0: GHG concentration emitted from anaerobic filter tank system and stabilization pond system in swine farms were not related to each other.

H_1: GHG concentration emitted from anaerobic filter tank system and stabilization pond system in swine farms were related to each other.

RESULTS

The results of this research can be described in accordance with objectives of the study. Followings are detail of the results found in this study: -

1. Investigation of GHG concentration emitted from wastewater systems in swine farms

1.1 GHG concentration emitted from anaerobic filter tank system in swine farms

The concentration of CO_2 and CH_4 emitted from six swine farms having anaerobic filter tank system in the study area is shown in Table 1. It was found that the concentration of CO_2 measured from 09.00 to 10.00 am. in the morning and from 15.00 to 16.00 pm. in the afternoon were averaged at 1,235.2 and 1,459.8 ppm. whereas the minimum and maximum concentration were between 57.0 to 5,545.0 ppm. In the case of CH_4 which measured by the same process as CO_2, the average concentrations of this GHG were found at 1,295.8 and 1,114.9 ppm. in the morning and in the afternoon with the minimum and maximum concentration at 11.3 and 5,924.0 ppm., respectively.

Table 1 Concentration of CO_2 and CH_4 emitted from anaerobic filter tank system in swine farms of Chacoengsao province, Thailand

Farm No.	CO_2 (ppm)		CH_4 (ppm)	
	09.00-10.00 am	15.00-16.00 pm	09.00-10.00 am	15.00-16.00 pm
AF 1	4,058.0	**5,545.0** [2/]	**5,924.0** [4/]	5,440.0
AF 2	75.0	**57.0** [1/]	13.0	**11.3** [3/]
AF 3	101.0	88.0	39.0	42.0
AF 4	187.0	137.0	26.6	28.8
AF 5	525.0	424.0	88.6	76.7
AF 6	2,465.0	2,508.0	1,683.5	1,090.9
Average	1,235.2	1,459.8	1,295.8	1,114.9
Total average	1,347.5		1,205.4	

Remark: [1/] and [2/] represent the minimum and maximum concentration of CO_2 emitted from anaerobic filter tank of six swine farms.

[3/] and [4/] represent the minimum and maximum concentration of CH_4 emitted from anaerobic filter tank of six swine farms.

1.2 GHG concentration emitted from stabilization pond system in swine farms

The concentration of CO_2 and CH_4 emitted from six swine farms having stabilization pond system in the study area is shown in Table 2. It was found that the concentration of CO_2 measured from 09.00 to 10.00 am. in the morning and from 15.00 to 16.00 pm. in the afternoon were averaged at 9,782.9 and 9,949.8 ppm. whereas the minimum and maximum concentration were between 2,755.0 to 28,662.0 ppm. In the case of CH_4

which measured by the same process as CO_2, the average concentrations of this GHG were found at 6,016.7 and 6,255.2 ppm. in the morning and in the afternoon with the minimum and maximum concentration at 1,500.0 and 16,109.6 ppm., respectively.

Table 2 Concentration of CO_2 and CH_4 emitted from stabilization pond system in swine farms of Chacoengsao province, Thailand

Farm No.	CO_2 (ppm)		CH_4 (ppm)	
	09.00-10.00 am	15.00-16.00 pm	09.00-10.00 am	15.00-16.00 pm
SP 1	3,788.0	6,985.0	4,909.0	7,555.0
SP 2	7,455.0	8,520.0	2,065.4	**1,500.0** [3/]
SP 3	10,551.0	7,830.0	8,430.8	7,963.5
SP 4	4,929.0	**2,755.0** [1/]	2,645.5	3,017.5
SP 5	3,952.0	4,947.0	1,940.0	1,875.0
SP 6	28,022.5	**28,662.0** [2/]	**16,109.6** [4/]	15,620.2
Average	9,782.9	9,949.8	6,016.7	6,255.2
Total average	9,866.4		6,135.9	

Remark: [1/] and [2/] represent the minimum and maximum concentrations of CO_2 emitted from stabilization pond of six swine farms.

[3/] and [4/] represent the minimum and maximum concentrations of CH_4 emitted from stabilization pond of six swine farms.

1.3 GHG concentration emitted from both anaerobic filter tank and stabilization pond systems in swine farms

The following Tables shows the concentration of both CO_2 and CH_4 emitted between two periods of time, 09.00 to 10.00 am. in the morning (Figure 1) and 15.00 to 16.00 pm. in the afternoon (Figure 2), from anaerobic filter tank and stabilization pond systems of twelve swine farms. It can be concluded that CO_2 and CH_4 concentration emitted from stabilization pond system both in the morning and afternoon were much higher than those emitted from anaerobic filter tank system.

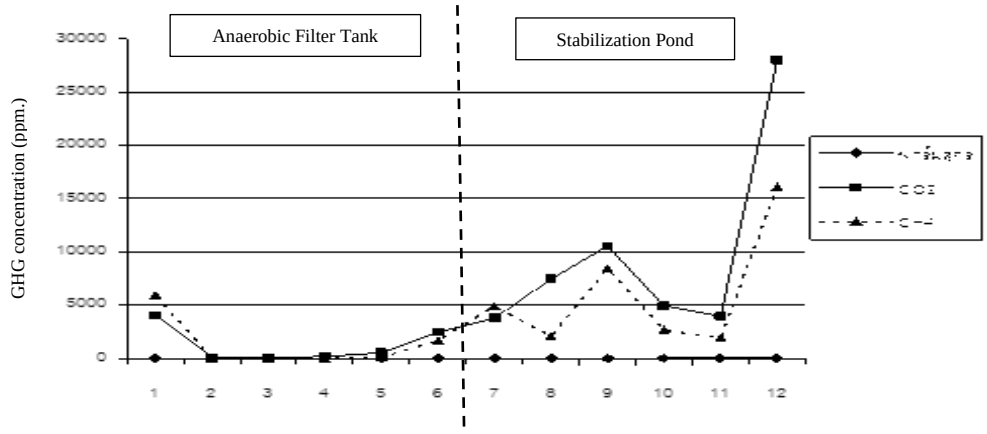

Figure 1 Emission of CO_2 and CH_4 from anaerobic filter tank and stabilization pond system of swine farms (09.00 – 10.00 am.)

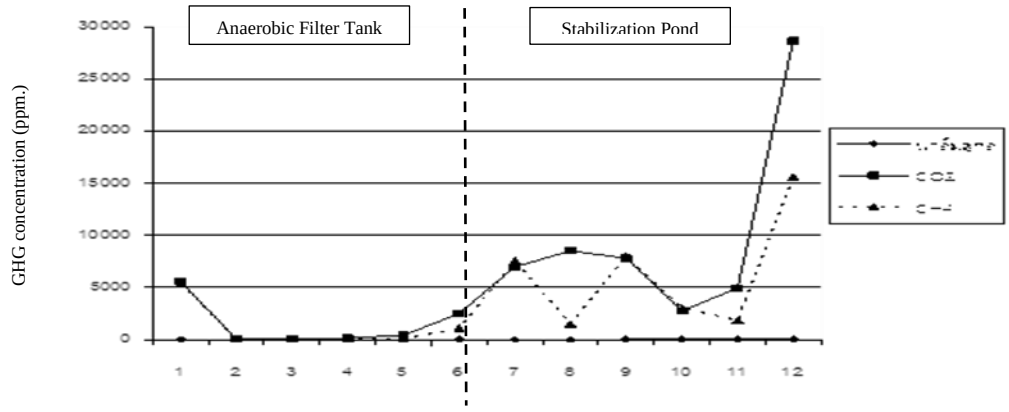

Figure 2 Emission of CO_2 and CH_4 from anaerobic filter tank and stabilization pond system of swine farms (15.00 – 16.00 am.)

2. Comparison of GHG concentration emitted from different wastewater treatment systems in swine farms

2.1 Comparison of CO_2 concentration by different wastewater treatment systems

Table 3 shows the comparison of CO_2 concentration by different wastewater treatment system of swine farms in the study area. It was found that the concentration of this greenhouse gas emitted from anaerobic filter tank system and stabilization pond system were statistical different at the significant level of .05 [Sig. (2-tailed) = .007 < α (.05)] in which CO_2 concentration emitted from stabilization pond was much higher than that emitted from anaerobic filter tank by the total average concentration of 9,866.4 and 1,347.5 ppm., respectively.

Table 3 Comparison of CO_2 concentration by different wastewater treatment systems in swine farms

Wastewater System	Mean ($\overline{X}$)	t	Sig. (2-tailed)
Anaerobic filter tank	1,347.5	-3.239 *	0.007
Stabilization pond	9,866.4		

Remark: * statistical different at the significant level of .05

2.2 Comparison of CH_4 concentration by different wastewater treatment systems

Table 4 shows the comparison of CH_4 concentration by different wastewater treatment system of swine farms in the study area. It was found that the concentration of this greenhouse gas emitted from anaerobic filter tank system and stabilization pond system were also statistical different at the significant level of .05 [Sig. (2-tailed) = .009 < α (.05)]. In this case, CH_4 concentration emitted from stabilization pond was also much higher than that emitted from anaerobic filter tank by the total average concentration of 6,135.9 and 1,205.4 ppm., respectively.

Table 4 Comparison of CH_4 concentration by different wastewater treatment systems in swine farms

Wastewater System	Mean ($\overline{X}$)	t	Sig. (2-tailed)
Anaerobic filter tank	1,205.4	-3.034 *	0.009
Stabilization pond	6,135.9		

Remark: * statistical different at the significant level of .05

3. The relationship between the concentration of CO_2 and CH_4 emitted from different wastewater systems in swine farms

Table 5 shows the relationship between CO_2 and CH_4 concentration emitted from both anaerobic filter tank system and stabilization pond system in swine farms of the study area. As a result, it was indicated that CO_2

and CH_4 concentration were related to each other at the significant level of .01 [Sig. (2-tailed) = .000 < α (.01)] with the correlation coefficient (r) of .925. It means that the concentration of these two gases will change in the same direction. That is, if the concentration of CO_2 increase, the concentration of CH_4 will also increase, and vice versa.

Table 5 Correlation coefficient analysis between CO_2 and CH_4 concentration emitted from wastewater system in swine farms

	CO_2 concentration	CH_4 concentration
Pearson correlation coefficient (r)	1.000	.925**
Sig. (2-tailed)	.	.000
N	24	24

Remark: ** Correlation is significant at the 0.01 level (2–tailed)

CONCLUSIONS

The aims of the comparative study on greenhouse gas emission from livestock farming with different wastewater treatments in Chacoengsao province, Thailand were to investigate and compare the concentration of CO_2 and CH_4 emitted from anaerobic filter tank system and stabilization pond system in swine farms and also to indicate the relationship between the concentration of these two gases emitted from those systems. The results of this study showed that concentration of both CO_2 and CH_4 emitted during 09.00 to 10.00 am. in the morning and 15.00 to 16.00 pm. in the afternoon of a day from stabilization pond system were much higher than those emitted from anaerobic filter tank system. When compared the concentration of these two gases emitted from different wastewater treatment systems, it was found that those concentrations were statistical different at the significant level of .05. In addition, this study also indicated that the relationship between CO_2 and CH_4 concentration emitted from both anaerobic filter tank system and stabilization pond system in swine farms were related to each other at the significant level of .01 with the correlation coefficient (r) of .925.

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REFERENCES

[1] Hopwood, N. and Cohen, J. (2007). *Greenhouse Gases and Society.* Retrieved August 26, 2007 from http://www. umich.edu/~gs265/society/greenhouse.htm.

[2] Office of Natural Resources and Environmental Policy and Planning. (2014). *National Strategies for Climate Change Management, B.E. 2551-2555***.** Bangkok: Ministry of Natural resources and Environments.

[3] Pollution Control Department. (2003). *Manual for the Operation of Wastewater Treatment System in Swine Farm.* Retrieved March 25, 2019 from http://infofile.pcd.go.th/water/swine.pdf?.

[4] Pollution Control Department. (1999). *Handbook of Swine Farm Management for Environmental Protection***.** Bangkok: Ministry of Natural resources and Environments.

[5] Department of Livestock Development. (2014). *Statistical Data of Swine Population in Thailand.* Retrieved March 15, 2019 from ict.dld.go.th/th2/images/stories/stat_web/yearly/2557/book2557/05.pdf.

[6] Tamprateep, M. (2018). *Current Situation of Livestock Industry and Livestock Wastewater in Thailand*. Retrieved March 25, 2019 from http://wepa-db.net/3rd/en/meeting/20171130/pdf/2-2_Maytawee Tamprateep.pdf.