The Initial Study of Environmental and Health Impact for the Laying Hen Farm in Chiang Rai Province

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Abstract

The aim of this study is to examine the environmental and health impact from a layer chicken farm in Chiang Rai Province. The methodology consisted 1) the observation of process in laying hens farm, 2) the survey from the people affecting with the health and environmental impact, 3) the analysis of environmental parameters including the total suspended particulate matter (TSP), PM 10, accumulated noise, and wastewater analysis. These results were concluded to the focus group discussion between the people affecting the health and environmental impact and the owner of layer hens farm to prevent the environmental and health problem.

From this study, it is concluded that 23.9% of the people in a community faced the odor problem from a layer chicken farm although the environmental parameters were not higher than the environmental standard. Moreover, there was a high concentration of ammonia and total nitrogen in wastewater characteristics. In addition, the results form the focus group indicated that the system of ammonia and nitrogen removal in wastewater and particle collected system should install to prevent the environmental problem. In the future, this farm should address the several technologies for reduce these problems, i.e. the air stripping for ammonia removal and water in this farm.

Keywords: Environmental Analysis, Environmental and Health Impact Assessment, Environmental Responsibility

Introduction

Chicken eggs are agricultural products that are constantly demanding of consumers and providing several essential nutrients and minerals to maintain of life including protein (approximately 12.0-12.8 grams of protein from two eggs), phosphorus, iodine, and vitamin B2, and linoleic acid (Tanjor, Saiwan, Puwastien, Deeaum, & Judprasong, 2015). In addition, Thailand has a chicken and product development policy committee to promote and support the quality of the production and marketing in the laying hens (Kasetsart University Chalermphrakiat Sakon Nakhon Province Campus, 2018). As a result of the COVID-19 epidemic, in March 2020, the demand for chicken eggs increased from the previously duration. This was due to two main reasons: 1) a warm weather and drought which resulted in lower level of egg production, and 2) reserved demand from COVID-19 prevention measures (Kasikorn Research Center, 2020). In the northern of Thailand, the data from the Department of Livestock Development (2020) found that Chiang Rai province has several of laying chickens as the second ranks of the North, with a total of 2,468 laying farmers and 1,518,221 of laying hens. It is implied that Chiang Rai province has a relatively high potential for laying hens production to serve the needs of consumers

The "A" laying hens farm (fraudulent name), located in Chiang Rai Province, is a hen farm that breeds lay eggs for sale in Chiang Rai and nearby areas. There are a total of 8 chicken houses which can raise more than 100,000 laying hens. However, the operation of this farm has been complaints from villagers living nearby

area. According to the results of the survey from the local government organization in this area in 2017, it was found that 54 villagers living near the area of the laying hens farm had been affected by the operation of this farm accounted for 29.82%. In addition, both of bad smell disturbing and noise problem was also affected in this area regarding as 22.80%. Moreover, the good agricultural practice for layer farm (National Bureau of Agricultural Commodity and Food Standard, 2019) is not provided any information for the environmental standard and management. In addition, the study of Sedavi, Zaker-Esteghhamati, and Scanes (2019) stated that the chicken excreta can release the ammonia and nitrous oxide affecting the greenhouse gas emission, and some pathogen may contaminate with ground water if they lack a proper of wastewater treatment. According to the laboratory analysis from the program of Environmental Health, School of Health Sciences, Mae Fah Luang University, it found that the screening results of the wastewater from this farm is the higher than the effluent standard. To sum up, it is difficult to control the environmental quality in the layer hen farm due to the lack of a guideline for environmental management in the layer hen farm. Hence, a researcher team in this program has come up with the idea addressed the environmental and health problems from the operation of the laying hen farm to study the environmental and health issues. This will not only create the guidelines for environmental health prevention and improvement from this farm, but the villagers in this area will also survive without any harmful environmental impacts on their health. The objective of this research is to study the initial impact assessment for the environmental and health issues based on the production process of a layer hens farm "A" in Chiang Rai province, Thailand.

Methodology

For the methodology of this study, the research team has performed and divided into 4 activities, which are:

1) Analysis of the production process of laying hens farm

The first step is to analyze the production process of the laying hen farm. The research team conducted a site survey to analyze the inputs, processes, and outputs in order to identify environmental issues or *environmental aspects* (Sun, Cardaso, & Driml, 2020) as shown in Figure 1.

Figure 1 Process flow diagram for identifying the environmental assessment in laying hens farm

2) Community survey for environmental and health issues

The research team collected data by using questionnaires for community leaders and 21 represntatives of households from the totally 150 households of this community which they had been affected from the operation of the "A" laying hens farm. The questions of this survey were included as follows(adapted from Tantakarnapa & Maneechot, 2020): 1) general information of the respondents, 2) general economic and social conditions, 3) utilities and infrastructures, 4) nuisance received from the operation of laying hens farm, and 5) recommendations on the prevention and remediation of the impacts of laying hens farm operations. By

information from the questionnaire, the descriptive statistics such as number and percentage were analyzed using the SPSS program 21st version (Order Number: 0054268990, Purchase Order: 10-58878). For the ethic consideration, the experimental protocol no. CRPPHO 62/2563 was approved by the Ethics Review Committee for Research Involving Human Research Subjects, Chiang Rai Provincial Health Office.

3) Environmental sampling and analysis

The research team collected environmental samples to analyze the environmental impacts from this operations as follows:

(3.1) Wastewater sampling from the operation of the "A" laying hens farm

To analyze the characteristic of wastewater in this, wastewater from the "A" laying hens farm was collected according to the standard of wastewater examination by the American Public Health Association, American Water Works Association, & Water Environment Federation (2012). It contains the amount of oxygen used by microorganisms to decompose organic matter (BOD), the amount of oxygen used to oxidize organic matter (COD), pH , total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3-N), total solids (TS), and volatile solids (TVS). In this study, the influent wastewater of this laying hens farm was collected to analysis to study the wastewater characteristic before the anaerobic digestion system.

(3.2) Analysis of noise accumulated from the operation of the "A" laying hens farm

This method was collected by measuring at the source of noise and the areas affected by noise using a Sound Level Meter. It is a measurement of the accumulated noise level in the environment using the 24-hours average or Leq 24 hr. Moreover, it has a unit of measurement of accumulated noise in decibels A (dBA) (Office of Natural Resources and Environmental Policy and Planning, 2018). The criteria of this analysis was follow the guideline of the Pollution Control Department (2014) that the representative of the accumulated noise should select the point source and the household that has an effect from this noise (see in figure2). For the calculation of the sound volume accumulated in this study, it can be calculated using the following the excel calculation following by the Pollution Control Department (2004).

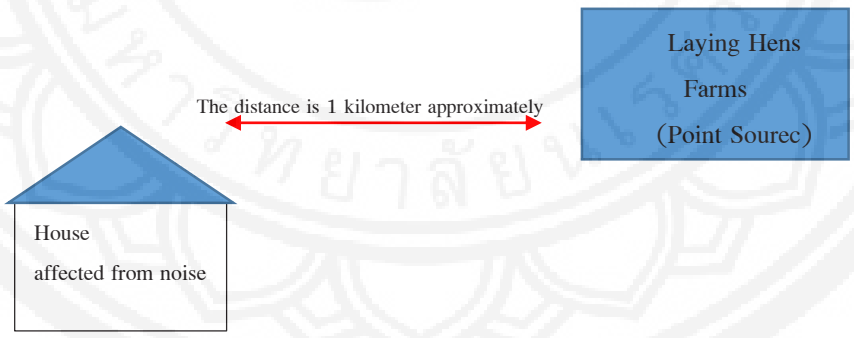

Figure 2 Sound Level installation in this study

(3.3) Particulate Matter Analysis

Particulate matter analysis in the "A" laying hens farm operations was indicated as the gravimetric measurement including 1) a large particulate matter with a diameter of 100 micrometers namely as the *Total*

Suspended Particulate (TSP), and 2) the particulate matter with an aerodynamic dimeter less than or equal to nominal 10 micrometers namely as *PM10* (Pollution Control Department, 2014).

4) Focus group

After the community survey and the environmental sampling and analysis, the researchers will use the results of these studies to hold public consultations on the process of *focus group* (Nyumba, Wilson, Derrick, & Mukherjee, 2018) on environmental issues and nuisances affecting public health. The inclusion criteria for this focus group is followed by the experimental protocol no. CRPPHO 62/2563 which were 1) they had been affected from the operation process of this laying hens farm, and 2) they should communicate or respond when the question was asked by the researcher. Hence, several stakeholders were invited in this focus group to summarize the appropriate approach to reduce the environmental impact from the activities of laying hens farm, including 1) local government official, 2) community leaders and household affected from this laying hens farm, and 3) the laying hen farm owner.

Results

4.1 Analysis of the production process of the "A" laying hens farm

The results of the analysis of the production process of this laying hen farm described as 40,000 hens, is now closed for renovations, with a total of 21 fans installed, a 1.5-horsepower fan per unit, a fan fitted with an automatic control system. This farm set at temperature 28-29 degrees Celsius, humidity 70-80%. In addition, this laying hen farms also use anaerobic wastewater treatment system to treat the wastewater arising from chicken manure. The treatment system can also produce biogas that can be used as a fuel to generate electricity in the farm. However, the problem encountered from this wastewater treatment system was that the effluent from the system was further treated in three aeration ponds, where aerators were used to improve treatment efficiency. Therefore, the stench from the farm had been released that one is a main nuisance to the villagers in the surrounding area. At the present, this laying hen farm has already covered every pond with HDPE plastic sheet as can be seen in figure 4 to prevent the overspread of stench from the farm operation.

Figure 4 The anaerobic wastewater treatment of the "A" laying hens farm

4.2 The result of the community survey

From the community survey, the demographic information of the household affected by the operation process of this laying hens farm can concluded that they graduated from the primary school. Moreover, most of households have an agriculture, and 30% of this sample has an income lower than 3,000฿ per month.

For the results of community survey about environmental and health nuisances arising from this laying hen farm or 21 households, it found that 66.7% were affected by particulate matter at only the sometime. Moreover, 40% of the affected households were affected by noise only at the sometime. In addition, 42.9% were affected by wastewater in the farm which will only be found sometimes during the rainy season. In contrast, only 4.8% stated that they were affected by solid waste at only the sometime.

In addition, the results of questioning about the health problems arising from the expected effects of the laying hen farm as can be seen in table 1, it was found that the majority of more than 60% did not find any health problems. However, nearly 24% have been affected by health, especially the stench from this farm caused health effect. Moreover, they were allergies and shortness of breath from this farm representing as 4.8% equally.

Table 1 Health problems from the operation of the "A" laying hens farm

	n=21	
Health Problems	**Frequency**	**%**
The stench	5	23.9
Allergies	1	4.8
Shortness of breath	1	4.8
Do not find any health problems	14	66.6

4.3 The result of environmental analysis

The results of the analysis of the influent wastewater of the laying hen farm collected from the mixed wastewater and manure before releasing to the anaerobic treatment pond as shown in Table 2. It was found that the organic concentration of wastewater (BOD and COD) was very high with BOD at 2,020 ± 200 mg/L and COD at 28,200 ± 2,400 mg /L, respectively. For the total Kjeldahl Nitrogen (TKN), it had content up to 12,700 ± 1,600 mg /L. Moreover, the concentration of ammonia nitrogen in the wastewater was up to 1,000 ± 100 mg /L.

Table 2 The result of wastewater analysis for the "A" laying hens farm

Parameter (Unit)	**The result from wastewater analysis (the sampling is the mixed wastewater for anaerobic treatment)**	**The method of wastewater examination**
BOD (mg/L)	2,020 ± 200	5 days BOD test (5210-B)
COD (mg/L)	28,200 ± 2,400	Closed dichromate reflux method
TS (mg/L)	29,000 ± 1,800	Gravitational method
TVS (mg/L)	16,100 ± 600	Gravitational method
TKN (mg/L)	12,700 ± 1,600	Automatic distillation unit machine (UDK149, VELP SCIENTIFICA, USA).

Table 2 (Cont.)

Parameter (Unit)	The result from wastewater analysis (the sampling is the mixed wastewater for anaerobic treatment)	The method of wastewater examination
NH_3-N (mg/L)	1,000 ± 100	Automatic distillation unit machine (UDK149, VELP SCIENTIFICA, USA).
pH	7.3 ± 0.2	pH meter
DO (mg/L)	0.2 ± 0.03	DO meter

Note: The method of wastewater examination is referred to the American Public Health Association, American Water Works Association, & Water Environment Federation (2012)

For the particulate matter analysis, it is shown that the average TSP of this laying hen farms was 93 micrograms per cubic meters, and the average PM 10 of this laying hens farm was 56 micrograms per cubic meters. With regarding the results of TSP and PM 10, it can conclude that the particulate matter from this laying hens farm is under the standard while the standard of the average TSP and PM10 in Thailand is 330 and 120 micrograms per cubic meters respectively. Similarly to the result of accumulated noise analysis, it is stated that the point source had 50.75 dBA of the average of accumulated noise in 24 hours; meanwhile, the household affected from the operation of this farm had 66.3 dBA of the average of accumulated noise in 24 hours. Therefore, the average of accumulated noise in this farm is not affected to the community because the average of accumulated noise from this farm is under the standard which the average of accumulated noise is not over 70 dBA.

4.4 The result from the fucus group

From the focus group from the relevant stakeholders as can be seen in figure 5, they recommended that the laying chicken farm should take the major action to resolve the stench from the farm. This is consistent with the results of the study on the characteristics of wastewater in the "A" laying hen farms which it found the high concentration of ammonia and TKN in the wastewater of this farm. Similar to the farm owner, he said that

"Base on the results, I will solve my wastewater treatment to reduce the stretch of this process"

Moreover, this farm should resolve the problem of particulate matters, especially in the agricultural area near the location of the "A" laying hen farm. They hope that any health and environmental problems of the operation at this farm may be reduced in the future. Similar to the representative of the household affected from this farm, she said that

> *"I sill face the problem of dust because my rubber farm is near this laying hens farm. I see a lot of dust come from this laying hens farm. So, please set the equipment to reduce a tremendous of dust."*

Figure 5 The focus group of this study

Discussion

From this study, it was found that the people in the area were affected by the particulate matters of the laying hen farm. Moreover, they have been affected by the stench from the anaerobic wastewater treatment. According to the study of Kongapirug (2012), it found that people in the area were concerned about disease vectors, the bad odor, and the noise pollution at the significant level. It also corresponds to the results of the focus group in the area, they wish to this laying hens farm provide an action to resolve the problem of stench of the "A" laying hen farm. Generally, it can be caused by two sources (Pollution Control Department, 2011). The first is chicken house, there will be a large amount of manure accumulated over a long period of time over the manure collection period approximately 45 days while laying farms are scooped for about 3 months. Moreover, the odor intensity depends on the humidity level according to the ventilation rate and the house type of farm. However, the odor concentration is also high when the humidity is high. If the humidity is greater than 70%, the odor concentration is about 50% higher than at the humidity level, up to 10 times higher than at the humidity level. The latter is dried or piled in open areas for sale as manure or produce as compost. If pampering in collecting the dry manure and leaving or leave it exposed to moisture and rain, it will make the high odor concentration. Similarly to the result of wastewater analysis in this farm, it was found that the organic content was up to high level, especially, the high volume of nitrogen content in wastewater (TKN and ammonia). This high nitrogen content results in an odor concentration in the mixing pond area leading to the deficiency of anaerobic wastewater treatment. In fact, the high volume of ammonia in the wastewater will result in inhibition of the growth of bacteria present in the anaerobic treatment system (Rajagopal et al., 2013). As a result, the treated wastewater retains a high organic concentration and nitrogen content. It should be designed to determine an appropriate and effective method of removing nitrogen from this wastewater.

As the matter of the particulate matter analysis, it was found that the average of particle size of TSP and PM10 did not exceed the standard affecting to the health; for example, Cerebrovascular disease Chronic obstructive pulmonary disease, Ischemic Heart Disease, Lung Cancer, or Lower Respiratory Acute Infection (US EPA, 2018). However, particulate matter generated on the laying hens farm may affect the problem of global warming in the future (Kalhor, Rajabipour, Akram, & Sharifi, 2016). Therefore, this laying hen farm may have to install additional particulate matter or dust collection systems such as a water distribution curtain system (Pollution Control Department, 2011). This installation can trap the particulate matter in the laying hens farm ,and it also reduce the ammonia gas emitted from the laying hen farm (Min et al., 2020).

For the results focus group, it can indicate that the "A" laying hens farm operator provide sincerity of environmental problems from their operation affecting the people in the area although the process did not begin

with the construction of the laying hen farm. It is associated with the principle of public participation in environmental impact assessment. As a matter of fact, the comprehensive environmental impact hearing on stakeholders before the laying hens farm construction is the best approach to prevent the environmental conflicts and impacts between the owner and the villager in this area (Office of Natural Resources and Environmental Policy and Planning, 2019). Furthermore, environmental problems and complaints from residents to the operation in laying hens farm may be prevented and resolved in a timely manner. In addition, it will give a better attitude of people in this area towards to the laying hens farm when people in the area have a good knowledge and understanding. Hence, this hearing may also prevent public opposition to the activities of laying hens farm in the future (Pussadee Laor, Vivat Keawdounglek, Anuttara Hongtong, Yanasinee Suma, Nittaya Pasukphun, Tanika Songla2, and Wanvisa Saisanan Na Ayudhaya, 2019. ; Tantakarnapa & Maneechot, 2020)

Conclusion

The "A" laying hens farm located in Chiang Rai province, Thailand faced the complain with the community who had been an effected from the operation process of this laying hens farm, especially particulate matter, bad smell disturbing and noise problem.

This study focused on the community survey, the environmental analysis from the operation of this laying hens farm to find out the main points of the environmental problem affecting to the health of the surrounding people living in this area. From this study, it is concluded that 23.1% of household had the stench from the laying hens farm operation process, while the accumulated noise level and the particulate matter from this farm did not exceed from the environmental standards. In contrast, the influent of wastewater in this farm had the high volume of nitrogen content resulting in an odor concentration and leading to the deficiency of anaerobic wastewater treatment.

Furthermore, the results of this analysis were illustrated in the focus group to discuss the suitable approach for reducing and preventing the environmental and health impact from the operation process of this laying hens farm. It is summarized that this laying hens farm should install an appropriate treatment process for wastewater treatment. Moreover, some of equipment that can collect the particulate matter from this farm should address to reduce the impact from any particles.

Recommendation for the further study

1. The laying hen farm should use an appropriate treatment process for removing nitrogen in chicken farms, such as heat, air stripping, pH adjustment in treatment systems (Bousek, Scroccaro, Sima, Weissenbacher, & Fuchs, 2016, David, Domnanovich, & Holubar, 2006, Meng et al., 2018).

2. The laying hens farms should address the effect of particulate matters from their operations by the installation of the equipment for collecting and reducing the amount of particulate matter.

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References

American Public Health Association, American Water Works Association, & Water Environment Federation. (2012). *Standard Methods for the Examination of Water and Wastewater* (22nd ed.). The United States of America: American Public Health Association.

Bousek, J., Scroccaro, D., Sima, J., Weissenbacher, N., & Fuchs, W. (2016). Influence of the gas composition on the efficiency of ammonia stripping of biogas digestate. *Bioresource Technology, 203,* 259-266.

David, P. B. T. B. S., Domnanovich, A. M., & Holubar, P. (2006). A pH-based control of ammonia in biogas during anaerobic digestion of artificial pig manure and maize silage. *Process Biochemistry*, *41*, 1235-1238.

Department of Livestock Development. (2020). *Livestock Database.* Retrieved from http://ict.dld.go.th/webnew/index.php/th/service-ict/report/340-report-thailand-livestock/reportservey2563/1460-2563-month

Kalhor, T., Rajabipour, A., Akram, A., & Sharifi, M. (2016). Environmental impact assessment of chicken meat production using life cycle assessment. *Information Processing in Agriculture*, *3*(4), 263-271.

Kasetsart University Chalermphrakiat Sakon Nakhon Province Campus. (2018). *Element of egg.* Retrieved from shorturl.at/yFKM1

Kasikorn Research Center. (2020). *Demand of egg in COVID-19 situation.* Retrieved from https://kasikornresearch.com/th/analysis/k-econ/business/Pages/z3095.aspx

Kongapirug, A. (2012). *Impact of laying hen farm pollution on health status of people in Ban Phae Mae Fak Mai Village and Ban Che Di Pat Tha Nar Village, Mae Fak Mai Sub-district, San Sai District, Chiang Mai.* Retrieved from https://tdc.thailis.or.th/tdc/browse.php?option=show&browse_type=title&titleid=317240&query=%CD%D1%AD%AA%CA%D2%20%A4%A7%CD%C0%D4%C3%D1%A1%C9&s_mode=any&d_field=&d_start=0000-00-00&d_end=2563-07-22&limit_lang=&limited_lang_code=&order=&order_by=&order_type=&result_id=1&maxid=1

Min, D. S., Choi, S., Oh, E-Y., Lee, J., Lee, C-G., Choi, K-Y., & Jung, S. (2020). Numerical modelling for effect of water curtain in mitigating toxic gas release. *Journal of Loss Prevention in the Process Industries, 63,* 1-7.

National Bureau of Agricultural Commodity and Food Standard. (2019). *Good Agricultural Practice for Layer Farm.* Retrieved from https://www.acfs.go.th/standard/download/GAP_Layer_Farm(G)_2562.pdf

Nyumba, T. O., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Method in Ecology and Evaluation*, *9*, 20-32.

Office of Natural Resources and Environmental Policy and Planning. (2018). *Manual of noise detection*. Retrieved from http://eia.onep.go.th/images/monitor/1532577645.pdf

Office of Natural Resources and Environmental Policy and Planning. (2019). *Guideline of public participation for environmental impact assessment* . Retrieved from http: / / www. onep. go. th/ eia/ wp-content/uploads/2019/02/KMPP0162.pdf

Pollution Control Department. (2004) . *Excel sheet for noise calculation*. Retrieved from http://pcd.go.th/Info_serv/air_ExcelNoise.html

Pollution Control Department. (2011). *Manual of odor prevention from layer chicken farm*. Bangkok: Pollution Control Department.

Pollution Control Department. (2014) . *Process of PM 10 Measurement*. Retrieved from http: / / infofile. pcd. go. th/ air/ 200257_1. pdf?CFID= 2503990&CFTOKEN= 53083730 Pussadee Laor , Vivat Keawdounglek , Anuttara Hongtong , Yanasinee Suma , Nittaya Pasukphun , Tanika Songla, and Wanvisa Saisanan Na Ayudhaya. (2019). Health risk and health status of farmers exposed to chemical pesticides used in agriculture. *Journal of Current Science and Technology*, *9*(2) , 89-98.

Rajagopal, R., Massé, D. I., (2013). Singh G. A critical review on inhibition of anaerobic digestion process by excess ammonia. *Bioresource Technology*, *143*, 632-641.

Sedavi, A., Zaker-Esteghhamati, H., & Scanes, C. (2019). Present and potential impacts of waste from poultry production on the environment. *World's Poultry Science Journal, 75*(1), 29-42.

Sun, Y- Y., Cadarso, M. A., & Driml, S. (2020). Tourism carbon footprint inventories: A review of the environmentally extend input-output approach, *Annals of Tourism Research*, *82*, 1-13.

Tanjor, S., Saiwan, T., Puwastien, P., Deeaum, A., & Judprasong, K. (2015). Nutritive value of commonly consumed eggs and effects of cooking. *Journal of Science and Technology*, *Thammasart University*, *23*(4), 651-666.

Tantakarnapa, K., & Maneechot, K. (2020). *Environmental Impact Assessment and Management*. Bangkok: Ake IT Copy Service.

US EPA. (2018) . *Health and Environmental Effects of Particulate Matter*. Retrieved from https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm