



Unit mass estimation and characterization of litter generated in the broiler house and slaughter house



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ABSTRACT

A study was undertaken to characterize various broiler litter and to estimate the waste mass at every detailed process. Also, the usefulness of broiler litter (from the broiler house and slaughter house) as a fertilizer, feedstuff, and a solid/gas fuel was evaluated. The conclusions from this research are as follows: The unit mass of litter from the broiler house was calculated to be 58.6 L [10³heads]⁻¹ day⁻¹, and this waste satisfied the legal standards which are applied to fertilizer. The litter from the slaughter house was a very useful source of feed and renewable energy (e.g. solid fuel or biogas). The high calorific value of sludge cake, especially, reached more than 6500 kcal kg⁻¹. The results of the biochemical methane potential (BMP) test of sludge cake from the slaughter house showed that the 676 ml of methane was produced (at 1 atm and 35 °C) for 1 g of VS added. This value represents 90% of its theoretical methane potential.

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1. Introduction

Within Korea, there has been a recent improvement in people's lifestyle and income, and consequently, the consumption of meat has increased. In 2011, there were 852,565 cows, 10,833,042 pigs, and 759,609,670 chickens led to slaughter in Korea. This figure for pigs is reduced due to the impact of foot-and-mouth disease during this period, yet compared to 2009, these figures represent an increase of about 13.3% for cows and 4.7% for chickens (MIFAFF, 2012). Also, it is expected that such trends will be continued. Currently, the consumption of chickens has increased steadily due to the recent surge in interest and marketing related to health and well-being, and the number of chickens slaughtered in the country has increased by about 50% compared to figures from 2003. Also, in other countries, broiler chicken production has undergone steady growth both in developed and especially in developing countries during the past 40 years (Sims et al., 2005).

Also, if the manure production from livestock is estimated, it is based on the unit mass of manure discharge. The area for the

treatment and storage of manure within each farmhouse is also estimated based on the unit mass of manure discharge. And the statistics of the manure production from livestock are calculated by the unit mass of manure discharge. Therefore, the exact numbers in such unit mass estimations are very important. In Korea, the unit mass discharge of livestock (pigs, cows, horses, and milk cows) manure was first reported by the ministry of environment (MOE) of Korea in 1999. The Korea Swine Association and similar authorities were then asked to re-estimate the unit mass of manure discharge for each type of livestock, considering the specific domestic conditions of the animals, the changes in feeding conditions, and improvements of livestock management technology. The MOE reported the unit mass discharge re-estimation, with the inclusion of chickens within the report in 2008, after conducting a survey of livestock manure production over 4 seasons for 2 years (Table 1). As above, the unit mass of manure discharge for chickens was firstly estimated and suggested in 2008, and this estimation has not been adjusted since. The method of manure collection for chickens is very different from that of pigs or cows, and it is required to more accurately estimate the unit mass discharge on site.

After the broilers are grown, and all feeding stages have been completed, they are moved to the slaughter house for slaughter. Here, the term slaughter includes all of the processes involved in

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Table 1
Livestock manure unit mass for different kinds of livestock in Korea.

Livestock kind	Beef cattle horse (L head ⁻¹ d ⁻¹)	Dairy cattle (L head ⁻¹ d ⁻¹)	Pig (L head ⁻¹ d ⁻¹)	Layer chicken (L [10 ³ heads] ⁻¹ d ⁻¹)	Broiler chicken (L [10 ³ heads] ⁻¹ d ⁻¹)
(a) 1999					
Feces	10.1	24.6	1.6	NR	NR
Urine	4.5	11.0	2.6	NR	NR
Wash water	0.0	10.0	4.4	NR	NR
Sum	14.6	45.6	8.6	NR	NR
(b) 2008					
Feces	8.0	19.2	0.87	NR	NR
Urine	5.7	10.9	1.74	NR	NR
Wash water	0.0	7.6	2.49	NR	NR
Sum	13.7	37.7	5.10	124.7	85.5

(a) notice from ministry of environment of Korea (in 1999), (b) official results of the research about livestock manure unit mass (in 2008). NR, not reported.

producing chicken meat, such as the removal of feathers, giblets, and any other waste materials. Slaughtering by-products occur from the slaughtering process of broilers, and they are mostly recycled into various forms of animal feeds. Also, much water is used in the slaughtering process, and wastewater with many organic pollutants is produced through this process. The highly concentrated organic wastewater is ultimately processed into sludge cake after wastewater treatment processing. As above, high volumes of pollutants occur from the slaughtering process as well as the feeding process of broilers. However, the pollutant production characteristics of the slaughtering process have not been reported, either within Korea, or further afield, until now.

This study aims to estimate the unit mass discharge for each pollutant source through the investigation of pollutant production from the feeding and slaughtering of broilers, and to provide basic information by the analysis of pollutant characteristics. Especially, the litter occurring from the feeding process of broilers, and the sludge cake occurring from the slaughtering process, have high fuel values for use in renewable forms of energy generation, and we have forecasted solid fuel and biogas potentials from each waste product. The biogas production potential has been estimated by the biochemical methane potential (BMP) test.

2. Materials and methods

2.1. Description of the sites

We selected 4 broiler houses and 4 operational slaughter houses for the unit mass estimation and characterization of litter generated in each (Fig. 1). In order to account for any geographical variables which might present within the results, broiler houses and slaughter houses were selected from different provinces within Korea.

In Korea, the feeding period of broilers in the broiler house is 30–42 days, which is shorter than other countries. Generally, Korean boiler houses produce broilers of 30 days for a soup only, and of 35 days for sale as white meat only. This study targeted broiler houses for 30 days, 1 broiler house is 35 days, and is the remaining broiler house for 42 days, the sizes of which were 20,000–50,000 head per house for a single cycle. Feeding conditions within the 4 broiler houses were similar. Rice hulls, sufficient to cover the floor of the broiler house, were used as the bedding material, and broiler chicks entered the house at a density of 10 ± 2 heads m^{-2} . The broilers are removed after the feeding period (30–42 days), and total litter, including the mixed rice hulls, is removed. Litter, which is a combination of manure, bedding materials, feathers, and remains of feed, is then replaced with fresh bedding for the next cycle. The feeding house is lit most of the time, except for 2–3 h at night, and this is to produce broilers with an improved texture, rather than

broilers of a maximum size. The U.S. system of broiler production uses normal ambient lighting or the blackout system, under which birds are kept in 95% darkness to reduce their movement, presumably enhancing the rate of weight gain (Sistani et al., 2003).

The four slaughter houses selected for the study were located throughout the country, the capacity of which was 45–80 million heads per year. We targeted larger-sized slaughtering houses to obtain the reliable result for unit mass estimations and a more accurate characterization of the litter generated in the slaughtering process. Currently, the slaughtering process is almost standardized throughout the country, as the slaughtering equipment is standardized. The slaughtering equipment is focused on productivity, and automated high-speed systems are preferred. 4 slaughter houses targeted for the study have the similar auto-slaughtering system, and their slaughtering processes are the same.

2.2. Unit mass estimation of litter generated in the broiler house and slaughter house

Broilers excrete feces and urine at the same time (Han et al., 2008), and hence, they are estimated as one figure. Also, due to the feeding conditions, bedding materials are necessarily incorporated into the manure upon collection. Therefore, the unit mass discharge for manure only cannot be accurately estimated, and is an

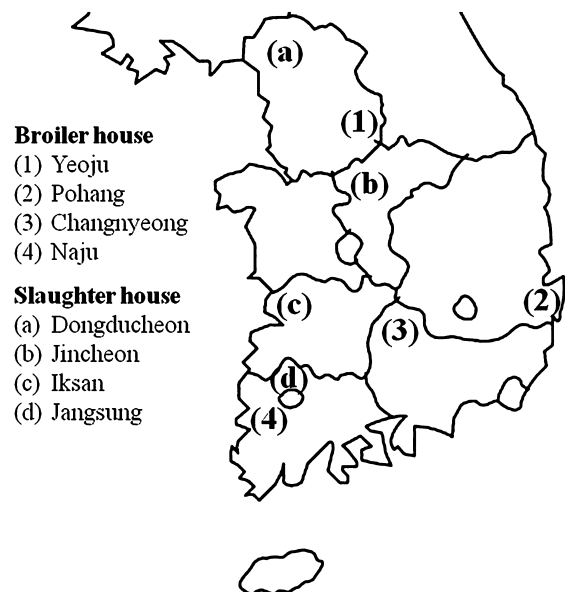


Fig. 1. A map of sampling sites in South Korea. The numbers indicate the sampling sites of the broiler house. The letters indicate the sampling sites of the slaughter house.

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