THE ENVIRONMENTAL IMPACT OF BROILER CHICKEN MANURE MANAGEMENT IN BULUKUMBA, INDONESIA

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1. Introduction

The number of broiler chickens in Indonesia increased tremendously in the past years, and 3 billion heads were produced in 2019[1]. Bulukumba Regency in Indonesia dominated small-scale chicken farming and was the eighth producer of broiler chicken in South Sulawesi[2] in 2020. An increase in the broiler chicken population has led to a corresponding increase in the quantity of chicken manure. Although chicken manure is a source of organic fertilizer, its improper treatment induces environmental degradation such as acidification, eutrophication and global warming. Several studies estimated greenhouse gas (GHG) emissions from chicken farming[3]; however, no data is available regarding GHG emissions from small-scale broiler chicken farming.

The present study aims to estimate GHG emissions and assesses the environmental impacts of the manure management system (MMS) of small-scale broiler chicken farming in Bulukumba, Indonesia, applying Intergovernmental Panel on Climate Change (IPCC) Guidelines and partial life cycle approaches.

2. Outline of Broiler Chicken Farming System in Bulukumba Regency

The total area of Bulukumba is approximately 1100 km², with 438,000 inhabitants spread across 10 sub-districts. More than 500 broiler chicken farmers are in Bulukumba Regency, and most of them have signed contracts with agri-food companies such as chicken processing companies, chicken breeding companies and food producers. These companies provide chicks, feeds, and primary equipment, loans, technical assistance, and medicines for the farmers. In the Bulukumba Regency, the farmers produce farm chicks until they reach the slaughter weight. Then, the broiler chickens are purchased by large broiler chicken processing companies for slaughtering, processed or supplied through distributors.

3. Research Method

3.1. System Boundary

Figure 1 outlines the systems analysis. System boundary in this study is manure management activities of the farm, manure transportation and land application. CH_4 and N_2O emissions were calculated based on Asia IPCC Guidelines, 2006. The functional unit (FU) was 1 kg of live weight of broiler chicken.

3.2. Inventory analysis

Inventory data for the analysis were collected from 77 broiler chicken farmers in the study area. The data was obtained through an interview survey. The questions comprised of outlines of broiler chicken farmers (broiler chicken population, type of house, rearing period and land ownership) and manure management (frequency of discharge of manure, type of manure utilization, equipment to discharging of manure, characteristics of manure).

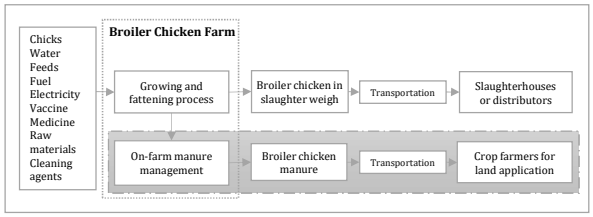

Figure 1. System boundary of this study

Table 1. House type and manure management of broiler chicken farmers

Housing system	*Open house*	*99%*
	Closed house	*1%*
Land ownership	*Private*	*94%*
	Rented	*6%*
Manure management	*Without litter*	*99%*
	With litter	*1%*
Equipment to discharge manure	*Manual*	*100%*
Frequency of manure removal from the house	*Once/flock*	*99%*
	Twice/flock	*1%*

Table 2. Farming characteristics of chicken broiler farmers in the study area

Broiler chicken population	*847,100 (5,510)*	*heads*
Broiler chicken production	*1,607 (11.1)*	*tons*
Quantity of manure sold	*730 (7)*	*tons*
Rearing period	*26-50 (4.38)*	*days*

The value in the parenthesis shows the standard deviations

4. Results and Discussions

4.1. Manure management system

Table 1 presents the house types and manure management of the respondents. Almost all respondents use opened house farming system, in which manure is discharged without any bed materials, such as rice husk and wood shaving. The manure drops directly to the ground under the cage. Nearly 99% of farmers cleaned the manure from the house once when the farming period was completed, and all the farmers collected the manure manually. Before the collection, the manure under the house is left for a few days to reduce the moisture content, revealing that the type of house and manure management of chicken broiler farmers in Bulukumba are nearly homogeneous.

Table 2 shows the general information of respondents. The average number of broiler chicken populations was 11,000 heads. In neighbouring areas such as Sinjai and Bantaeng Regencies, the broiler chicken population in 2020 was approximately 278 million and 1.04 billion heads, respectively[2]. Therefore, the farmers of broiler chicken in the study area were relatively small scale. The rearing period was approximately 26-50 days per flock. The

Table 3. Utilization of broiler chicken manure

Manure Utilization	Percentage (%)*
Sold to crop farmers	83
Given to neighbors	53
Utilize in their own land without prior process	68
Utilize in their own land after composting	4

*Because of multiple answers allowed, the total is not 100%.

Table 4. Distribution of broiler chicken manure

Manure Distribution	Average Distance
Within sub-district	4 km
Other sub-districts	36 km
Other regencies	81 km

Table 5. GHG emissions on MMS per FU

On-farm manure management	
CH_4	$1.13 \cdot 10^{-3}$ kg
N_2O	$1.43 \cdot 10^{-6}$ kg
Manure transport	
CO_2	65.3 kg
CH_4	$3.11 \cdot 10^{-2}$ kg
N_2O	$3.01 \cdot 10^{-3}$ kg
Land application	
N_2O	$2.51 \cdot 10^{-4}$ kg

average number of productions reached 20.87 tons of live birds, and the quantity of manure sold to the crop farmers was 9.47 tons per broiler chicken farm.

Table 3 shows the broiler chicken manure utilisation. About 83% of farmers sold the manure to the crop farmers, who used it as an organic fertilizer. Table 4 shows the distribution of sold manure based on the average distance. The manure was distributed within Bontotiro Sub-District with an average distance of 4 km. The other parts of manure were transported to other sub-districts and regencies, and the average distances were 36 and 81 km, respectively.

The broiler chicken manure spread to the cropland at the beginning of the growing season. Based on the interviews, it is mainly used as fertilizer for vegetables, maize and rice paddy.

4.2. Environmental impact of MMS

Default emission factors of IPCC and activity data from surveys were used to calculate CH_4 and N_2O from aerobic and anaerobic decomposition processes[5]. Based on the estimation of GHG emissions from manure transportation, the vehicles fuel consumption was based on the average fuel consumption of new light-duty vehicles in Indonesia, which was 7.9 litres of gasoline per km[6].

Default emission factors for gasoline, to estimate CO_2, CH_4 and N_2O from manure transportation, were 69,300 kg CO_2/TJ, 33 kg CH_4/TJ and 3.2 kg N_2O/TJ, respectively[7]. GHG emissions from manure applied to soils consist of direct and indirect nitrous oxide (N_2O) emissions from manure nitrogen (N)[5]. Table 5 shows the results of GHG emissions on MMS per functional unit. The largest source of emission was from manure transportation, with 65.3 kg CO_2/FU, $3.11 \cdot 10^{-2}$ kg CH_4/FU and $3.01 \cdot 10^{-3}$ kg N_2O/FU.

Table 6. Global warming potential (GWP) of broiler chicken manure management

Sources	GWP (kg CO_2-eq/year)	GWP per FU (kg CO_2-eq/year)
On-farm manure management	$2.50 \cdot 10^{3}$	$1.56 \cdot 10^{-3}$
Manure transport	$1.08 \cdot 10^{8}$	66.97
Land application	$1.20 \cdot 10^{5}$	$7.49 \cdot 10^{-2}$
Total	$1.08 \cdot 10^{8}$	67.04

The emission load from the manure management system is shown in Table 6. MMS in broiler chicken farming contributed to Global Warming Potential (GWP) with 67.04 kg of CO_2-eq per FU. Assuming that the broiler chicken manure management is homogenous, the total GWP from all broiler chicken farmers in Bulukumba was $2.94 \cdot 10^{11}$ kg CO_2-eq/year.

5. Conclusions

A tremendous increase in broiler chicken population in Bulukumba, Indonesia has increased the quantity of manure. The improper treatment of broiler chicken manure has provoked environmental degradation. The inventory data of MMS in small-scale broiler chicken farming was obtained through an interview survey. GHG emissions were estimated from the data collected. The highest GHG emissions were generated during manure transportation to the crop farmers.

The manure transportation from chicken broiler farmers to crop farmers contributed to the major source of GHG emissions from small-scale chicken broiler farming. To reduce GHG emissions from manure transportation, the optimisation of the distribution of the manure is required, with the balance between supply and demand. Future studies should assess the effects of replacing mineral fertilizer with broiler chicken manure in cropland to reduce GHGs.

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