The Analysis Life Cycle Assessment on Dairy Farming Production System

A. Atabany[1], B.P. Purwanto[1], S. Purwanto[1] and W. Al Zahra[2]
[1]Faculty of Animal Science Bogor Agriculture University, Japan, [2]Graduate School Faculty of Agriculture, Ibaraki University, Japan
Corresponding email: afton.atabany@yahoo.co.id

ABSTRACT

Animal production system was affected by the environment. However it was the point on the assessment of sustainability animal production in the future. Recently, there was an increasing of animal productions products (milk), due to awarness of people to consume milk. Life cycle analysis (LCA) is an integrated method to evaluate an environmental impact assessment. Therefore the objective of this research was to analyze the environment effect on dairy production system by using LCA method. This research was conducted in Field Experimental Research, Bogor Agriculture University.The energy flow and energy supply-demand were emphisized on this research. The energy flow was calculated from solar energy used on the forage to the energy used by the cattle. Further, we also observed the energy used on the dairy product (milk). The remaining product such as animal and feed wastes was also calculated. Furthermore the amount of energy flow consumed by the cattle was 791 Kcal.This amount was utilized to maintenance, production and feces. It was calculated that the amount of energy for maintenance was covered around 48.26% of total energy input, moreover energy used to produce milk was 31.41% and 20.32%of energy was excreted throught feces, respectively. Our results suggested that the probability of the highest of environment effect might occured in maintenance process in dairy cattle.

Key Words: Life cycle analysis, Dairy cattle, Energy flow

INTRODUCTION

The agricultural sector uses large amounts of energy and is responsible for 14% of total global greenhouse gas (GHG) emission (EC, 2009), since the animal industry is as the part of agricultural sectors and roles in providing food in the future. The increment of society awareness to consume food from animal industry become the latest trend recently, showed by the high number of milk consumption as the one of the indicator. It is well calculated that in 2001, milk consumption was only 883.758 ton and significantly increase to 1.758.243 in 2007. However, the production system of animal industry product leads to the environment effect. It becomes the core point to the sustainability assessment on animal production system in the future. This environment assessment should proved objectively and emphasize on the life cycle production. The environmental assessment could be done by using LCA method. The LCAmethod is a systems analysis method, as indicated by the occurrence of multidisciplinarity, teleological features, the presence of large (complex) systems and handling of a systems model, and the existence of case studies and their iterative nature (Tilman 2000; Bauman 1995). The LCA has become the established methodology for such analyses, and is today a recognised support tool for government organisations and businesses in decisions that concern climate and environment (EC, 2010). The LCA is a method of evaluating the environmental impact associated with a product, process or activity during its life cycle by identifying and quantitatively or qualitatively describing its requirements for energy and material, and the emissions and waste released to the environment (Berlin 2002). The animal production is highly connected with the process from how to produce feed, such as forage, bioprocess on feed consumption, animal waste management system to milk production. It's commonly well that LCA consisted of four main phase, such as (1) definition and goal of scoping area, (2) Life Cycle Inventory (LCI), (3) Impact Assessment (IA) dan 4)

Improvement assessment. The aim of this research is to analyse the Life Cycle Assessment (LCA) in animal production system, especially in dairy science.

MATERIALS AND METHODS

The LCA method could be very effective to connect the environmental effect from the use of material. The first step on LCA consisted of the collection of primary data. In this research we try to calculate the LCA analysis in production process. The primary data was collected to calculate the energy used in order to estimate the effect of animal production. The data collected were feed production and by product. In this research stage, the calculation of energy utilization was conducted for feeding supply. This research was applied on two different variance of forage, i.e : P. Purpureumand S. Splendida. The three levels of shading used were 0%, 60% and 80%. Three different fertilization systems (30 Mg/ha, 20 Mg/ha, and 10 Mg/ha) were implied. Three replications of each treatment were conducted. We also concerned on the harvest time for forage production. It was assumed that different harvest time might effect on energy used for the plant. The plant was harvested on 40d, 50d, and 60d. The method to analyze biomass was conducted. The proximate analysis was undertaken to evaluate the water, ash, protein and crude fibercontents of the plant.

The 2 years old dairy cattle were used in this research. Latin square design was implied by using four dairy cattle. Feed offered was 40 kg/heads/day with four different cutting sizes (control, 5 cm, 10 cm, 15 cm). The concentrate was also given as 4% of body weight /day. Feeding period was applied for 28 days, within first 14 days as adaptation period for the cattle. The microclimate in the cage such as temperature (°C), humidity (%), wind speed (m/s), radiation (kcal/m^2/h)was measured.

The energy measurement was conducted as the part of life cycle inventory in dairy cattle farming system. It was the difference from the energy obtained from sunlight and the utilization in dry matter based. Furthermore the energy was changed and utilized for milk production, animal waste and maintenance. However, the energy distribution for the dairy cattle was showed in equation 1.

$$\text{Energi Balance} = \sum_{n=1}^{k} IRM - \left(\sum_{n=1}^{k} DM_{Tot} - \sum_{n=1}^{k} DM_{rm} - \sum_{n=1}^{k} DM_{cons}\right) - \left(\sum_{n=1}^{k} MP - \sum_{n=!}^{k} Fes - \sum_{n=1}^{k} Mtc\right)$$

RESULTS AND DISCUSSION

The LCA is a standardised method for analysing the environmental impact (with a wide range of impact categories) of products or services (CEN, 2006). The dairy industy production has been grown up rapidly and also well organized. The organization of dairy industry consisted of farmers, feed meal, milk cooperation and also milk production. However, the organization of dairy industry leads to the environmental impact.

Goal and scoping in dairy farm production

In general, the animal production system lead to the effect of the environmental changes. The life cycle pointed on dairy farming production was started since management system (off farm) to the final product (on farm). It is become an objective assessment in dairy farming production and the environmental assessment. The scoping of dairy farming production consisted of (1) feeding application, (2) metabolizm process in the cattle, (3) milk production (4) animal waste resulted from cattle, including feces and urine. (Figure 1). The implementation of dairy farming production was highly related with LCA, within the process inside in resulting green feed, forage, bioprocess to consume feed, waste from the cattle, and milk production.

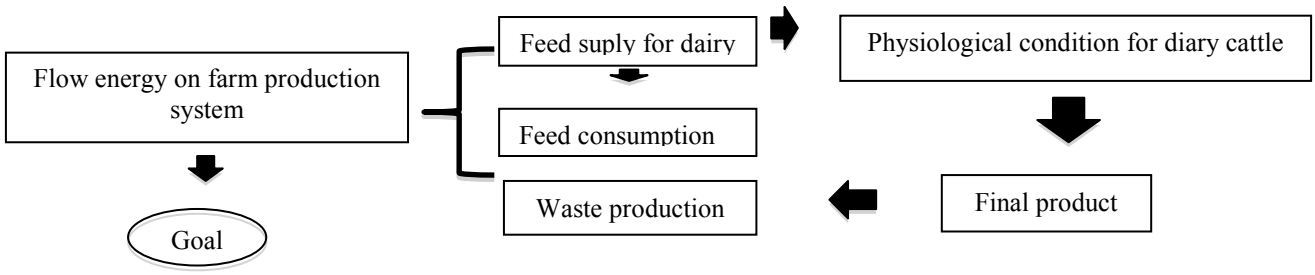

Figure 1. Goal and Scoping of LCA on dairy farming practices

Life cycle inventory (LCI)

In this research stage, the input identification from dairy farming practices was conducted. It is including raw material, or energy and the output in emission and waste form. The quantitative data was required to determine the level or the material input in dairy farming production. Further, it was used to understand the products that released to the environment. The LCI study was emphasised on how the cycle of dairy farming production brought an impact to the environment, and an effort should be done to minimize those impacts.

The data from environment condition indicated that temperature average on field area research was 28.44 ^{o}C with humidity around 77.75%. The wind speed discribed with the range of 0-1.6 m/second and radiation in the range of 0-995 watt/m^2.The energy from sunlight was accepting from forage. However, the dry matter production was highly influenced by shading level. It was calculated that the 0% level of shading wull produce the highest dry matter content, thus influenced the dry matter consumption by dairy cattle.

Table 1. The influence of size cutting on consumption, digestibility and milk production

Treatments (Cutting Size)	Consumption (kg/heads/day)	Digestibility (%)	Milk production (litre/heads/day)
A	43.988^{A}	79.345^{A}	7.1850^{A}
B	36.370^{B}	73.958^{B}	6.7350^{A}
C	33.590^{B}	73.950^{B}	4.8100^{B}
D	29.368^{B}	73.460^{B}	3.9000^{B}

Superscript in the different letters showed significant different ($p<0.01$). Treatments (cutting size).A (5 cm), B (10 cm), C (15 cm) and D (Control)

The data showed that the highest average of consumption, digestibility rate and milk production were obtained in 5 cm cutting size treatment. Based on ANOVA analysis, it could be seen that the difference in cutting size treatment showed a significant different in consumption, digestibility rate and milk production on dairy cattle. Further analysis was conducted by Tukey's method, and it could be seen that the cutting size for 5 cm leads to the highest values of consumption (43.988 kg/heads/day), digestibility rate (79.345%) and milk production(7.185 litre/heads/day). Further analysis was conducted on physiological analysis on dairy cattle due to the different cutting size treatments. The data showed that the smaller cutting size (5 cm) resulted in the higher number of consumption and digestibility rate. The physiological responses were not highly influenced by cutting size, unless on respiration respond. The 5 cm cutting size lead to the increasing in respiration rate compared to others cutting size. The energy on the plant is represented by gross energy. The analysis of gross energy is presented on Table 2. The analysis of energy flow in dairy cattle in off farm production system showed that the gross energy from forage was declining with the higher levels of shading. The calculation of energy flow also demonstrated that the ratio of energy flow utilized by the plant during growth period (maximum 50 days) was 1.43% from grand total of sun radiation. Furthermore, this number will be used for the material of dry matter production.

Table 2. The calculation of gross energy accepted by the forage from sun radiation

Elephant grass	Dry matter (%)	Gross Energy (cal /gram)
0% Shading Level	27.99	99.9
65% Shading Level	21.22	88.6
85% Shading Level	16.75	72.2

Table 3. The distribution of gross energy from animal feed, milk production and waste product

Cattle	Animal Feed	Milk production	Waste
		Kcal	
A	41.89	37.69	41.97
B	43.45	39.19	39.75
C	43.43	40.06	41.63
D	43.42	40.27	54.35

The total energy will be divided into (1) the energy consumed, as the calculation from the total energy in the cattle, and (2) the un-used energy, defined as the un-used energy from feed source. It was detected that, the energy consumedwas accounted for 791 Kcal , and then delivered to maintenance-primary production, in supporting basic life for the animal. The maintenance production consisted of reproduction, health and welfare, etc. The data showed that the energy used for primary production was 48.26% and this amount shall be distributed for milking as 31.41%. The observation also conducted in feces energy. It could be stated that the energy excreted throught feces was 20.32%.

CONCLUSION

The model on study of LCA in dairy farming production was required to describe, to analyze and to evaluate the dairy farming practices.The energy calculation was conducted from feed production, milk production and waste management system. The LCA could be very effective to connect the dairy production system from the material utilization and the output from dairy farming practice.

REFERENCES

Baumann H. Decision Making and Life Cycle Assessment.Licentiate thesis. 1995. Go¨ teborg: Chalmers University of Technology. Technical Environmental Planning Report 1995:4. (Also available as AFR Report 77. Stockholm: Swedish Waste Research Council.)

Berlin, J. 2002. Environmental life cycle assessment (LCA) of Swedish semi-hard cheese. international Dairy Journal 12 : 939–953

CEN, 2006. Environmental Management – Life Cycle Assessment-Principles and Framework (ISO 14040:2006). E.C. f. S. (CEN), Brussels.

EC, 2009.The Role of European Agriculture in Climate Change Mitigation.SEC (2009) 1093 Final. C. o. t. E. Communities, Commission of the European Communities.

EC, 2010.European Platform on LCA. http://lct.jrc.ec.europa.eu/eplca. Retrieved 25.04.14

Tilman A.M. 2000. Significance of decision-making for LCA methodology. Environmental Impact Assessment Review 20 : 113–123.