Improving nutrients in cattle manure by converting it into biogas sludge and compost

A Pertiwininingrum¹, M A Wuri², D Setiyana³, R Budiarto⁴, C A D Koranto⁵ and M Gozan⁶

1 Senior Lecturer, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia
2 Researcher, Centre for Development of Sustainable Development, Universitas Gadjah Mada, Yogyakarta, Indonesia
3 Student, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia
4 Senior Lecturer, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
5 Senior Lecturer, Faculty of Forestry, Universitas Gadjah Mada, Yogyakarta, Indonesia
6 Senior Lecturer, Faculty of Engineering, Universitas Indonesia, Depok, Indonesia

E-mail: artiwi@mail.ugm.ac.id

Abstract. In recent years livestock sector in Indonesia grows rapidly. As a consequence, organic waste will increase and cause environmental pollution and health problem if it’s not managed. The recycling of cattle manure for agriculture purpose can waste problem. Previous studies have suggested that the use of organic waste as bio-fertilizer is good for soil. The objective of this study was to investigate the difference between untreated and treated cattle manure on their chemical properties, especially nutrient elements. Untreated cattle manure, treated cattle manure by anaerobic digesting and composting were analyzed their chemical properties such as pH value, water and organic content, N-content, P₂O₅, and K₂O concentration. The pH value of fresh cattle manure, buried cattle manure, biogas sludge, and compost were 6.8; 5.4; 6.8; and 6.9 respectively. The C organic content in treated cattle manure decreased as compared to untreated cattle manure. On the other hand, N-content, P₂O₅, and K₂O concentration of treated manure were higher than untreated manure. The highest N-content, P₂O₅, and K₂O concentration were performed by compost from cattle manure.

1. Introduction
Livestock is growing as population growth. Livestock products provide one-third of food demand for example meat, milk, and egg [1]. Global production of meat is projected to more than 450 million tonnes in 2050. According to Directorate General of Animal Husbandry and Animal Health in Indonesia, cattle population has increased since 2013. The consequence of livestock growth is organic waste increases day by day. Organic waste is produced from their manure, feed residue, and agriculture waste. It becomes problem to environment or advantages to farmers depending on how to treatment these waste.
Livestock waste can populate in environment if these are not treat properly. Untreated livestock waste will generate negative impact to environment. For example, cattle manure, if these are not treat it will emits greenhouse gases (GHGs) emission. Greenhouse gases emission from livestock consist of non-
carbon dioxide (CO$_2$) and methane (CH$_4$). These gases were generated from biological activities in aerobic or anaerobic conditions. CO$_2$ is released largely from microbial decay or burning of waste while CH$_4$ is produced when organic materials decompose in oxygen-deprived conditions [2]. Over the period 2001-2011, global trends of livestock waste emissions increased about 10% [3]. Livestock waste in Indonesia has contaminated soil and air conditions so reduction contaminates action need to be developed. So far commonly livestock waste is used as bio-fertilizer or raw material of biogas especially livestock manure. Livestock waste can be used as compost but utilization of livestock waste to energy gives farmers more advantages such as saving energy from fossil fuel and getting free bio-fertilizer from biogas sludge. Bio-fertilizer can substitute conventional fertilizer because it has abundant nutrients, amino acids, bioactive substances [4]. The objectives of this study were to investigate and evaluate characteristics of compost and biogas sludge from cattle manure for their nutritional properties.

2. Methodology

2.1. Materials

This study was conducted in Universitas Gadjah Mada. Fresh and treated cattle manure that used in this study were obtained from Ngudi Mulyo livestock group, Yogyakarta. In Ngudi Mulyo these manure were processed into compost and biogas sludge in experimental chamber. Biogas sludge that used in this study was sludge which has been released from experiment chamber for a week and filtered from water content. The compost that used in this study was mature compost for 5 weeks.

2.2. Sample analysis

Fresh manure and treated manure were analyzed their nutritional properties such as water content, organic content, N-content, P$_2$O$_5$ and K$_2$O concentration, and pH value. Analysis of water and organic content were performed by gravimetric method while P$_2$O$_5$ and K$_2$O were analyzed by spectrophotometer. N-content was analyzed by Kjeldahl method.

3. Results and discussion

Livestock waste mainly cattle manure contaminates environment if it’s not treated well. On the other hand if it’s treated well, it would give more advantages. Currently, there are two main ways of processing cattle manure into useful product for farmer use, composting and biogas. Both of methods, organic material would be stabilized. In soil, compost may increase nutrient availability and enzyme activity while biogas may give alternative energy for cooking or lighting.

3.1 pH value

![Figure 1. pH value of fresh cattle manure, compost, and biogas sludge](attachment:image.png)
Characteristics of fresh manure, compost, and biogas sludge were presented by pH value, water content, organic content, N-content, P$_2$O$_5$ and K$_2$O concentration. Parameter of pH value was showed in Figure 1. Fresh cattle manure has pH value at 6.8, it’s not different from compost and biogas sludge at 6.8 and 6.9 respectively, close to neutral pH. The results showed that compost and biogas sludge in this study were safe to apply in soil. Microorganism that involved in composting and biogas process shifted pH value to close to pH neutral. This condition would be different if cattle manure is only buried, it would be acid pH. The longer the waste dumped, the more acidic of this waste [5]. For buried, cattle manure would degrade and generate organic acids that can decrease pH value. Acid condition of cattle manure is not good for fertilizer application.

3.2 Water content

Water content of fresh cattle manure, compost, and biogas sludge were presented in Figure 2. Water content of fresh manure is 79.92%. Lower water content was performed by biogas sludge of 78.62%. The lowest water content was performed by biogas sludge of 38.6%. It means the processing of cattle manure into compost and biogas sludge would decrease water content. The decrease in water content in biogas sludge was caused water content in cattle manure has been used for hydrolysis process of biogas production. Water in cattle manure was consumed by microorganism to convert organic material [6].

3.3 Organic content

Organic content is raw material that would be degraded by microorganism in aerobic or anaerobic condition. Based on this study fresh manure has the highest organic content compared to compost and sludge. Organic content of fresh manure is 72.29% while biogas sludge and compost are 62.45 and 32.91% respectively. These organic content showed that the process of composting and biogas would decrease organic content in fresh manure. Organic content in cattle manure has been converted to simple compounds by microorganism. The process of anaerobic decomposition will degrade organic material and convert to CH$_4$, CO$_2$, N, CO, O, hydrogen sulphide, ammonia, and nitrogen oxideso that organic content in biogas sludge decreased [7]. Enough organic content can fulfil the need of nutritional necessity of the microorganism [8]. The same results have been reported by Haryati [9].
3.4 Nitrogen content
Nitrogen content plays key role as fertilizer. Plants are utilized nitrogen for growing and cell renewal. Figure 4 was showed nitrogen content of fresh cattle manure, compost, and biogas sludge. Biogas sludge has the highest nitrogen content from all samples of 2.02%, followed by compost and fresh manure of 1.65 and 1.34% respectively. The increase in nitrogen content because organic content in cattle manure has been degraded. Biogas sludge is preferably as bio-fertilizer because chemical forms of N in biogas sludge are easier to be utilized by plants in short time [7] compared to compost and fresh manure. In addition, the increase of nitrogen content probably was caused by the adding of nitrogen from microbes.

3.5 $P_2O_5$ and $K_2O$ concentration
Phosphor and potassium are essential nutrition that needed by plants. Moreover, potassium is used by plant’s microorganism as catalyst. In this study, we also investigated of phosphor and potassium of fresh cattle manure, compost, and biogas sludge that presented by $P_2O_5$ and $K_2O$ concentration. $P_2O_5$ and $K_2O$ concentration from fresh cattle manure, compost, and biogas sludge were showed in Figure 5 and Figure 6 respectively.

The process of composting and biogas would increase phosphor concentration from 1.34% of fresh cattle manure become 1.35% of biogas sludge and 1.67% of compost. The increase in phosphor of
biogas sludge is not significant compared to compost. The same trend was performed in potassium concentration analysis. Potassium concentration if compost is the highest at 1.86% compared to fresh cattle manure at 1.38% and biogas sludge at 1.49%.

\[ P_2O_5 \text{ concentration (%)} \\
\begin{array}{ccc}
\text{samples} & \text{fresh cattle manure} & \text{compost} & \text{biogas sludge} \\
0 & 0 & 0 & 0 \\
0.6 & 1.2 & 1.8 & 1.8 \\
1.2 & 1.8 & 1.8 & 1.8 \\
1.8 & 1.8 & 1.8 & 1.8 \\
\end{array} \\
\]

\[ K_2O \text{ concentration (%)} \\
\begin{array}{ccc}
\text{samples} & \text{fresh cattle manure} & \text{compost} & \text{biogas sludge} \\
0 & 0 & 0 & 0 \\
0.5 & 1.0 & 1.5 & 1.5 \\
1.0 & 1.5 & 1.5 & 1.5 \\
1.5 & 1.5 & 1.5 & 1.5 \\
\end{array} \\
\]

Figure 5. $P_2O_5$ concentration of fresh manure, compost, and biogas sludge

Figure 6. $K_2O$ concentration of fresh manure, compost, and biogas sludge

4. Conclusions
Either compost nor biogas sludge can be used as bio-fertilizer in cropland. Compost could be regarded as soil conditioner that has enough minerals content from phosphor and potassium but has to be complemented with nitrogen content. However biogas sludge give good performance in nitrogen content compared to compost. It has been suggested to blend of two-thirds biogas sludge and one-third compost as efficient fertilizer [4]. The bio conversion of livestock waste to compost and biogas sludge should be recommended among farmer group to overcome livestock waste contamination.

5. References
[1] F N Tubiello, M Salvatore, R D C Golec, A Ferrara, S Rossi, R Biancalani, S Federici, H Jacobs, and A Flammini 2014 Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks (FAO, Food and Agriculture Organization)
[2] P Smith, D Martino, Z Cai, D Gwary, H Janzen, P Kumar, B McCarl, S Ogle 2007 Agriculture Climate Change 2007 Mitigation ed B Metz, O R Davidson, P R Bosch, R Dave, and L A Meyer (eds) (New York: Cambridge University Press) chapter 8 pp 497-540
[3] The Livestock, Environment and Development (LEAD) 2006 Livestock’s Long Shadow Environmental Issues and Options (FAO, Food and Agriculture Organization)
[4] K Svensson, M Odlare, and M Pell 2004 J. of Agri. Sci.142 461-467
Acknowledgments
The research was supported by Grant Program from Gadjah Mada University, Indonesia through PTUPT program. We gratefully acknowledge the support from USAID through the SHERA program – Centre for Development of Sustainable Region (CDSR). In year 2017-2021, CDSR is led by Center for Energy Studies - UGM. The authors also would like to thank the students of Faculty of Animal Science for the contribution in collecting the data.