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Submission date: 09-May-2022 05:11AM (UTC+0700)
Submission ID: 1831388783
File name: Converting.pdf (869.12K)
Word count: 4396
Character count: 21617

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To cite this article: S Amrullah *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **679** 012001

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IOP Conf. Series: Earth and Environmental Science **679** (2021) 012001 doi:10.1088/1755-1315/679/1/012001

Converting husbandry waste into liquid organic fertilizer using probiotic consortiums (*Lactobacillus* sp., *Rhodopseudomonas* sp., *Actinomycetes* sp., *Streptomyces* sp.)

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Abstract. A synthetic fertilizer caused negative effects on soil and the environment. Thus, this study aimed at producing liquid organic fertilizer from cow urine using probiotic consortium consisting of *Lactobacillus* sp., *Rhodopseudomonas* sp., *Actinomycetes* sp., and *Streptomyces* sp. This study used a different number of bacteria and fermentation time. Quality of liquid organic fertilizer (N, P, K, C/N, pH) was evaluated. The results showed that the N increased (1.0-2.3%) from days 1 to 12, and stagnant onwards. P increased (0.6-2.2%) with day 0 to 15, and stagnant until day 21. K increased (1.0-3.2%) with day 0 to 12, and stagnant until day 21. The C decreased (5.6-0.1%) with day 0 to 21. Furthermore, C/N decreased (5.62-0.03) from day 0 to 21. The pH increased (7.1-8.6) from day 0 to 21. On the other hand, N increased (1-2.54%) for an increase of microorganisms number (5-30 mL). P increased (1.2-2.2) for an increase in the number of microorganisms (5- 25 mL), and stagnant until 30 mL. The K increased (1.5-3.3%) in increments of 5 to 30 mL. C value decreased (0.3-0.1%) from 5 to 30 mL. Meanwhile, the C/N decreased (0.3-0.04) from 5 to 30 mL. The pH was between 8.3-8.5.

1. Introduction

The demand for agricultural commodities increased significantly every year due to the rapid growth of human population. FAO estimated that the food demands for developing countries including Indonesia increased by 60% in 2030 and double in 2050 [1], which are equivalent to the increasing of world production by 42% in 2030 and 70% in 2050 [2].

The increasing demand for food in the community has resulted in increasing food production in the agricultural sector. On the other hand, there have been very severe land degradation due to intensive agriculture practices. Soil, as is the main nutrient source for plants, has become unfertile because of lack of nutrients which are responsible for energy storage, electron transport, and enzyme activity as essential nutrients that affect the developmental cycle and metabolism of plants [3].

Currently, the use of synthetic fertilizers is the main choice to improve soil nutrients. As a result, excessive use of synthetic fertilizers causes a deficiency of soil core nutrients. Nutrients that can be fulfilled by synthetic fertilizers are only macro-nutrients such as N, P, and K, whereas to produce growth

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requires 13 complete main elements [4]. Of the 13 nutrients, there are 6 nutrients needed in large quantities (macronutrients), such as N, P, K, Ca, Mg, and S. 7 of them are nutrients needed in small quantities (micronutrients), such as Fe, Na, Zn, Mn, B, Cu, and Cl [5]. Micronutrients are essential for plant growth, where these micronutrients are key in shaping the morphology and anatomy of these plants. These micronutrients are often referred to as trace elements because their content in the dry matter does not exceed 0.01%. Lack of one of these micronutrients can cause disease and disrupt vegetation in plants [6]. Besides, the use of synthetic fertilizers on a large scale has jeopardized environment. Excessive use of synthetic fertilizers has harmed diverse beneficial microorganisms that fertilize plants. Also, the N element from synthetic fertilizers which cannot be absorbed by plants can negatively affect the soil. Where nitrogen is produced from the rest of fertilization and leaching can inhibit the growth of algae and kill marine life. Apart from that, nitrogen also contributes to greenhouse gas emissions. The impact caused by nitrogen is so significant that in 2018 a group of nitrogen experts determined that the world must halve the amount of nitrogen discharged into the environment to avoid the worst impact on wildlife [7]. With such problems, it is necessary to have the right steps to replace the synthetic fertilizers, with a more eco-friendly approach such as organic fertilizers.

Organic fertilizers such as compost, manure, and crop residues, have received attention in recent years, this is due to their ability to improve soil quality effectively [8,9,10]. Previous research has also shown that organic fertilizers can significantly suppress soil-borne diseases such as BW by inhibiting pathogen growth, increasing nutrient levels, and neutralizing soil acidity [11,12]. In the other researchers have also found that the rice straw biochar used can reduce BW of tobacco by improving physicochemical properties and increasing the diversity of beneficial bacteria in the soil [13]. On the other hand, some researchers reported that application of porcine porridge changed the composition of the soil microbial community and decreased the population of *R. solanacearum* [14]. With these data, the use of manure to become vegetable-based fertilizers with better characteristics for the agricultural sector can reduce the use of chemical fertilizers as well as restore some of the nutrients from agricultural production. The results of the use of organic fertilizers are products with better characteristics, such as adequate soil nitrogen content, increased soil nutrient concentration, increased pest safety, and also improved physical form of plant products so that they are easier to handle and store.

One source of organic fertilizer that can be used is cow urine waste. Cow urine contains good N, P, K, Ca, Na and C / N values, especially after the fermentation process. In addition, the pH of cow urine is more than 7, so using cow urine as liquid fertilizer can increase soil pH [15]. On the other hand, if cow urine is not used properly, it can cause negative impacts on the environment. Meanwhile, it is known that livestock waste is very dangerous for the environment. The cow urine can contaminate river basins in the Cikapundung area. Liquid livestock waste around the area can cause the watershed to have a BOD value of 981,388 mg / l and a COD level of 2970.3 mg / l. So by using cow urine as liquid organic fertilizer through a fermentation process using decomposing microorganisms such as *Lactobacillus* sp., *Rhodopseudomonas*, *Actinomycetes* sp., And *Streptomyces* sp. can improve soil nutrients, while avoiding environmental damage [16].

In this research, liquid organic fertilizer was produced from cow urine using a group of decomposer microorganisms consisting of *Lactobacillus* sp., *Rhodopseudomonas* sp. *Actinomycetes* sp., *Streptomyces* sp. The liquid organic fertilizer from the process is represented by the content of N, P, K and C organic fertilizers.

2. Material and method

2.1 Material

The raw material used in this study is cow urine waste obtained from cattle farming waste in Tojang Maju 3 Farmer Group, Lendang Nangka Village, Masbagik District, East Lombok Regency, West Nusa Tenggara, Indonesia. Meanwhile, the microorganisms used were Lactobacillus sp, Rhodopseudomonas, actinomycetes sp, Streptomyces sp. obtained from a shop that sells agricultural tools and materials in East Lombok Regency. In addition, molasses is also used as an addition to nutrients contained in liquid organic fertilizers such as sulfur, potassium, iron, and micronutrients from the original sugar cane. The

latter is the use of coconut water as a source of natural hormones auxin and cytokinins, which are hormones to stimulate plant growth.

The tool in this study is the Hitachi-Z-2000 Polarized Zeeman atomic absorption spectrophotometer as a testing tool for carbon elements. Meanwhile, to test the content of phosphorus in cow urine waste and liquid organic fertilizer, the Hitachi-Z-2000 Polarized Zeeman atomic absorption spectrophotometer was also used. To test the potassium content using a Flamefotometry. To test the nitrogen content of cow urine waste and liquid organic fertilizer is the Kjeldahl method. On the other hand, the pH value of cow urine waste and liquid organic fertilizer was tested with a pH meter PCE-228HTE. The elements of carbon, nitrogen, phosphorus, and potassium are carried out at the Gadjah Mada University Integrated Testing Research Laboratory. In addition to these test tools, several glass tools such as glass bakers are also used to measure the volume of raw materials. Besides that, a plastic bucket is also used as a fermentation reactor. The latter is used as a plastic filter to filter out impurities contained in liquid fertilizer.

2.2 Method

2.1.1 The effect of fermentation time to the quality of liquid fertilizer

This research was conducted by measuring cow urine as the main ingredient of liquid fertilizer. The cow urine used in this research is 10 litres. Volume measurement is done using a baker glass. After measuring the volume of used bovine urine, then counting the number of microorganisms used. The microorganisms used were 20 mL which contained Lactobacillus sp, Rhodopseudomonas, actinomycetes sp, Streptomyces sp. then the process is carried out by mixing 200 mL of molasses. After that, the coconut water was mixed as much as 1,200 mL. At the end of the process, fermentation is carried out in a bucket with a capacity of 10 litres and is tightly closed (anaerobic process). Liquid fertilizer quality testing was carried out at variations of time between 0, 3, 6, 9, 12, 15, 18, and 21 days using the same sample. At the end of the study, the quality of the liquid fertilizer was checked, with a focus on the elements N, P, K, C, C/N, and pH.

2.1.2 Effect of increasing the volume of organisms to the quality of liquid fertilizer

This research was conducted by measuring the amount of cow urine as the main ingredient of liquid fertilizer. The cow urine used in this study is fixed at 10 litres/sample. Meanwhile, the molasses used is still 200 mL. The coconut water used is 1,200 mL. The microorganisms used vary. In this experiment, variations in the number of organisms were used, namely 5, 10, 15, 20, 25, and 30 mL. The research was continued by mixing cow urine with coconut water, molasses, and microorganisms. After that, the fermentation process is carried out in a closed bucket with a 10 litre capacity (anaerobic process). At the end of the study, the quality of the liquid fertilizer was checked, with a focus on the elements N, P, K, C, C/N, and pH.

3. Result and Discussion

3.1 Research results of the old effect of cow urine fermentation on the quality of liquid organic fertilizer

From the results of this study, it can be seen that the fermentation time on the quality of liquid fertilizer products can be observed. Indicators of the quality of the liquid organic fertilizer produced can be seen from the values of N, P, K, C, and C / N values and the pH value of the fertilizer. Figure 1 shows the results of research on liquid organic fertilizer products from cow urine waste on variations in the length of fermentation time. The product indicators obtained were levels of N, P, K, and C.

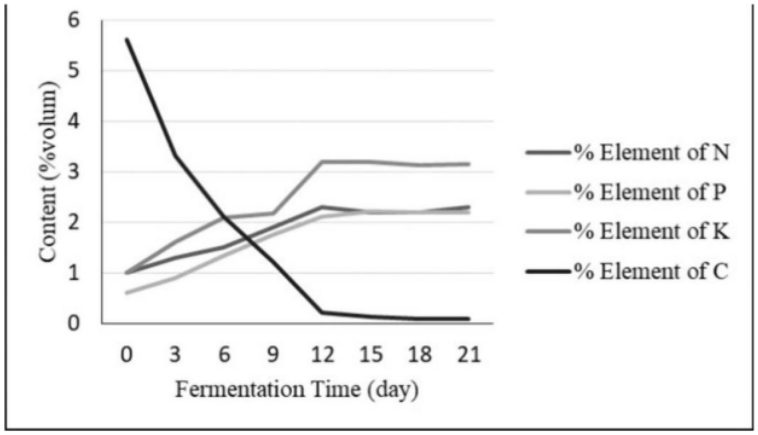

Figure 1. The effect of fermentation time to the quality of biofertilizer from the urine cow waste (N, P, K, and C content)

In Figure 1, it can be seen that the variation of cow urine waste fermentation time can affect the quality of liquid organic fertilizer products. Figure 1 shows that the increase in the total element N content from 1% to 2.3% at fermentation time of 0 to 21 days. In addition, the levels of phosphorus (P) in the form of P_2O_5 continue to increase with the longer the fermentation process takes place, this is because the consumption of carbon (C) grouper substrate continues to increase, increasing the value of P. The increase in P content occurs from day 0 to 15 of 0.6% to 2.2% and constant from day 15 to day 21. This means that from day 0 to day 15, there is still carbon consumption, but from day 15 to day 21 the carbon consumed has been used up. The levels of potassium (K) which are bound to the K2O compound also increase with increasing fermentation time. The results showed an increase in element K from day 0 to day 12 from 1 to 3.2%. And it tends to remain until day 21. This is because the carbon conversion increases from day 0 to day 12, and runs out until day 21. On the other hand, the element carbon (C) decreases with the longer the fermentation process takes place. This happens because the consumption of carbon by microorganisms is increasing, and it is used up at a certain time indicated by the C value declined continuously from 5.6% at day 0 to 0.1% at day 21. The results of this study are similar to research conducted by [17]. The results of his research showed that the greatest availability of nutrients in biological fertilizers occurred with longer fermentation time because in a short time there was no sufficient decomposition of biological fertilizers to release nutrients. In his research, fermentation was carried out for 60 days, so that it was considered to produce quality fertilizer.

For the effect of fermentation time of cow urine waste on the C/ N value of liquid organic fertilizer, it can be seen in Figure 2. Figure 2 shows that the C / N value decreases with increasing fermentation time. This was probably due to a decrease in element C and an increase in N levels with increasing fermentation time. The C/N value decreased from day 0 to day 21 from 5.62 to 0.03. This phenomenon occurs because carbon consumption by microorganisms continues when the fermentation time increases. Meanwhile, with the increasing fermentation time, the production of N occurs continuously until a constant state occurs, meaning that the substrate (carbon content) has been completely broken down into products. These results are similar to those expressed by [18,19]. The results of his research said that the longer the composting time, the smaller the C/ N value. This is because the longer the composting time lasts, the more C is consumed by bacteria as a source of energy. Oon the other hand, the longer the composting time takes place, the levels of N bound in nitrogen compounds continue to increase, this is because the process of decomposition of compost by microorganisms that produces ammonia and nitrogen continues to increase.

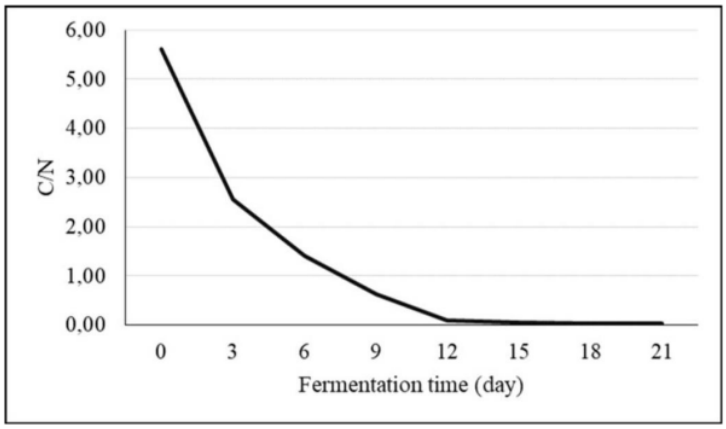

Figure 2. The effect of time fermentation of urine cow waste to C/N number of biofertilizer

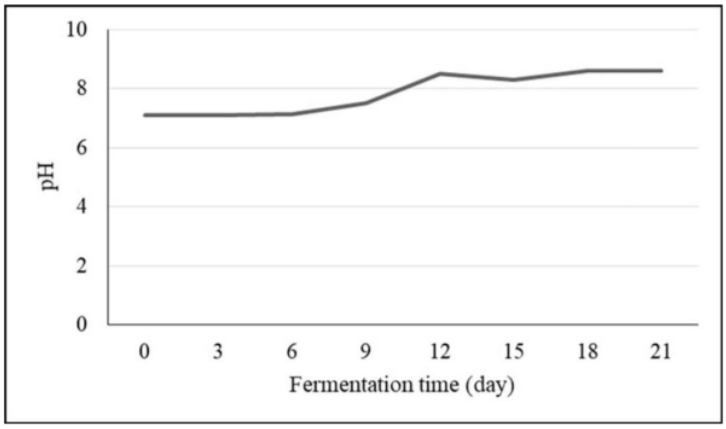

Figure 3. The effect of time fermentation of to pH value of biofertilizer

The pH value resulting from the fermentation process of cow urine waste into liquid organic fertilizer with increasing fermentation time is shown in Figure 3. Figure 3 shows an increase in pH which is not too significant when there is an increase in the fermentation time of cow urine waste into liquid organic fertilizer. The pH of the liquid organic fertilizers increased from 7.1 to 8.6 on day 0 to day 21. However, the resulting pH was still within the allowed standard range. The increase in pH that occurs is probably due to the addition of alkaline compounds. These compounds are such as K_2O [20] and NH_3 [21]. The results of this study are similar to the research conducted by [22]. This research showed that longer fermentation time resulted in the reduction of organic fertilizers pH, from 6.0 to 7.0. This is due to the increasing number of alkaline compounds produced.

3.2 Results of the effect of the number of organisms on cow urine fermentation on the quality of the resulting liquid organic fertilizer.

From this study, the effect of the number of microorganisms on the levels of N, P, K, and C produced in liquid organic fertilizer products is presented in Figure 4. Figure 4 shows that there was an increase

in the levels of N, P, and K with the increasing number of microorganisms. The increase in N levels from 1 to 2.54% with the addition of the number of microorganisms from 5 to 30 mL. P levels also continued to increase from 1.2 to 2.2% with an increase in the number of organisms from 5 to 30 mL. K levels also increased from 1.5% to 3.3% with the addition of the number of microorganisms from 5 mL to 30 mL. These three nutrient elements increased with an increase in the number of microorganisms. This can be seen from the equation for the speed of growth of microorganism cells. This equation can be seen in Equation 1 [3].

Substrate (C) + Microorganism (cells) → Extracellular Products (N, P, K) + new cells (1)

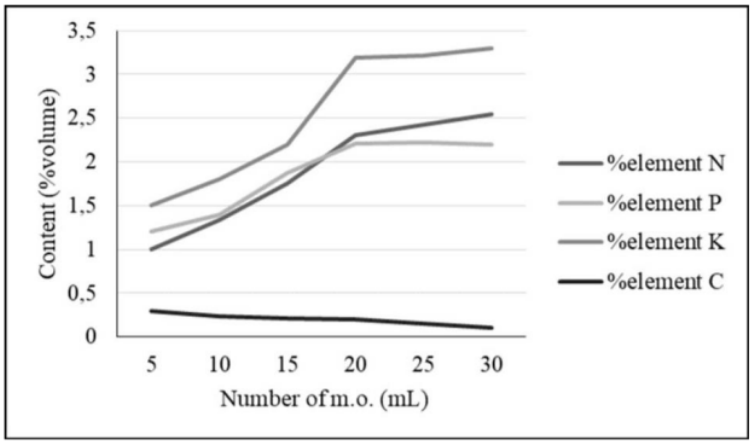

Figure 4. The effect of the number of a microorganism to quality of biofertilizer from cow urine waste (%N, %P, %K, and %C)

From equation 1, it can be seen that the number of microorganisms affected nutritional content such as N, P, K, and new cells from the microorganisms themselves [23]. The results of his research showed an increase in levels of N, P, and K with an increase in the number of fermented microorganisms. on the other hand, the C level shown in Figure 4 shows a decrease from 0.3% to 0.1% with decreasing levels of microorganisms added to the fermentation reaction (from 5 to 30 mL). This is based on Equation 1, thereby increasing the number of fermented microorganisms, the faster the consumption of C by microorganisms will occur in each variable the number of microorganisms at the same time (12 days).

The changes in the C/N ration of cow urine waste due to fermentation can be seen in Figure 5. Figure 5 shows a decrease in the C/ N ratio with the increasing number of microorganisms used. Figure 5 shows a decrease in the C/ N value from 0.30 to 0.04 with increasing the number of microorganisms from 5 to 30 mL. This happens because the more microorganisms cause the speed of carbon consumption to be faster. On the other hand, the production of N content increases when the microorganisms get bigger. This phenomenon is in accordance with Equation 1. Thus, the more microorganisms that carry out the fermentation process, the lower the C/ N value. The smaller the C/ N value indicates that the absorption of fertilizers by the soil is getting better. On the other hand, the decreasing C/ N value indicates that the increasing amount of N results in better plant growth, this is because the N element in fertilizers plays a role in the process of plant growth. The results of this study are similar to research conducted by Xue *et al*. [24]. The results of his research showed a decrease in the C / N number with the addition of the number of fermented microorganisms in the manufacture of organic fertilizer from pig manure.

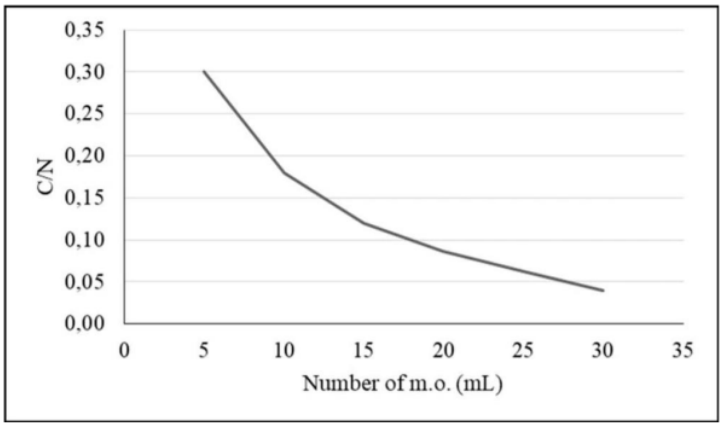

Figure 5. The effect of number of microorganism to C/N number of bio fertilizer from cow urine waste

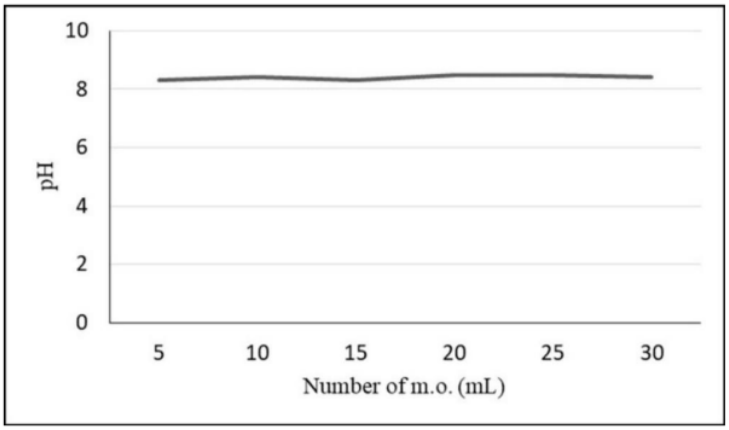

Figure 6. The effect of the number of the microorganism to pH number of biofertilizer from cow urine waste

The results of research on the effect of the amount of added microorganisms on the pH value of liquid organic fertilizers in the fermentation process of cow urine waste into liquid organic fertilizer are shown in Figure 6. Figure 6 shows the pH value of liquid organic fertilizer produced from the fermentation process of cow urine waste has slightly increased, from 8.3 to 8.5, with the addition of 5 mL to 30 mL microorganisms. This happens because of the addition of K_2O and NH_3 compounds. However, these two compounds are weak bases, so they do not affect the change in the pH value of the resulting liquid organic fertilizer. On the other hand, liquid organic fertilizer products also contain P_2O_5 compounds. P_2O_5 compounds when reacting with H_2O, will produce H_3PO_4 compounds which are acidic. This phenomenon is similar to the study produced by [25]. The results of his research showed that the increase in the number of microorganisms in the manufacture of organic fertilizers from urban organic waste caused an increase in the pH value of the fertilizer.

4. Conclusion

Organic fertilizer can be produced from husbandry waste with the help of fermentative bacterial consortium. In general, the bacterial fermentation has increased nitrogen (N), phosphor (P), and potassium (K) levels of cow urine after 12-day fermentation. On the other hand, the fermentation processes decreased carbon content of the cow urine from ~5.6 at day 0 to 0.1% after being fermented for 21 days. The pH value tented to fluctuate between 8.3-8.5. These results suggested that organic waste such as cow urine can be converted into organic liquid, although further studies need to be performed to get more comprehensive results.

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