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Efficiency of different decomposing methods for dairy farm wastes with indigenous enhancers

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Abstract

Farm wastes are neglected resources abundant in many dairy farms in northern Mindanao, Philippines. The study was conducted to evaluate the efficiency of utilizing the wastes generated in typical dairy farms for additional income. Manure and feed leftovers were decomposed under aerobic and anaerobic conditions with commercial probiotics, Lactic Acid Bacteria Serum, and Effective Microorganisms Activated Solution. The last treatment utilized vermicomposting method with African night crawlers. Data for the different parameters were analyzed using Analysis of Variance in Randomized Complete Block Design and Tukey's test to determine the significant differences among the treatment means. The yield of harvested composts and the number of days for the wastes to become desirable organic fertilizers were recorded. Compost quantity and quality, expected income generated, expenses spent, and return on investments were computed on an annual basis considering the length of time spent in composting. Results showed that costs were lower ($p>0.01$) when composting anaerobically than aerobically. ROI was comparable with vermicomposting and anaerobic composting, producing more compost with morphologically millions of bacteria, some protozoa, fungi, and nematodes. Through time, vermicomposting was most efficient ($p>0.01$) taking only two months to efficiently decompose with greater yield and three months with the other methods.

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Introduction

Dairy farms regularly gather forages and concentrate to feed the dairy stocks. In northern Mindanao, cut and carry is common which accumulates much feed leftover along the feed bunks. As cows were confined, they eat, digest their feeds and excrete manure and urine which accumulates in the farm producing undesirable odor while increasing the carbon footprints. About 1530kg of manure is produced per cow per year, contributing to the global environmental pollution with the emission of greenhouse gases. Simple aerobic composting is one of the most common method employed by dairy farms in northern Mindanao and according to (Komar *et al.,* 2012), it greatly reduces the overall volume of manure and produces fertilizer that ameliorates the pasture. Aerobic composting is also an effective strategy for reducing the spread of Antibiotic Resistance Genes (ARGs) which reduces the diversity of microbial population and ARGs, reducing the abundance of potential ARG host (Zhang *et al*., 2019). Anaerobic digestion of dairy cow manure for biogas and biomethane production according to Lauer *et al.* (2018) is economically viable for farms with at least 3000 cows. Jjagwe *et al.* (2019) demonstrated that vermicomposting has good potential in conserving nutrients and reducing GHG emissions. Total solids, ash, N, P, and K content significantly increased, while contents of volatile solids and C, as well as the pH, significantly decreased over time. The cattle manure composted with African night crawlers recovered 46% to vermicompost, 2% into earthworms, and 52% was lost to the atmosphere.

Wang *et al.* (2001) found the benefits of lactic acid fermentation in inhibiting the growth of putrefactive bacteria and food poisoning bacteria. Shehata *et al.* (2021) in their study of cattle and pig manure, found that composting is the most sustainable technology for reducing heavy metals, metalloids, and antibiotic residues while enriching the microbial community. These different methods employed to decompose dairy farm wastes were assessed for their efficiency and economics which will guide dairy farmers in their decision-making options.

Material and methods

Cattle manure and feed leftovers were the dairy farm wastes used in the study. Decomposing 100kg in each treatment was made for T_1 aerobic condition with commercial probiotics, T_2 aerobic condition with Lactic Acid Bacteria Serum (LABS) and Effective Microorganisms Activated Solution (EMAS) T_3 anaerobic conditions with commercial probiotics, T_4 anaerobic condition with LABS and EMAS and in T_5 vermicomposting.

Aerobic Decomposition

The compost bed was made with a 30:1 CN Ratio or 82% cow manure and 18% corn stalk piled and exposed to air. The 25kg of the mixed cow manure and corn stalk was added layer by layer and sprayed with the commercial probiotics in T1 and with LABS and EMAS in T2. These compost piles were turned every 10 days.

Anaerobic Decomposition

A 200kg capacity drum was used to maintain the anaerobic condition of composting with commercial probiotics for T3 and with LABS and EMAS for T4. The same enhancers were sprayed at every 25kg mixture to ensure better distribution.

Vermicomposting

The vermi beds used in vermicomposting were filled with the same volume and ratio of compost. African night crawlers were integrated in the dairy farm wastes and were covered with plastics and monitored regularly. Harvesting. Compost is ready for harvest when it looks dark brown, crumbly, smell like earth, and has a significant drop in volume.

Data Gathered. The yield of the compost was obtained from the total kg harvested from each treatment. The efficiency of composted manure was computed with the actual yield per batch on an annual basis. The costs were listed after preparing all the materials needed. Sales and Income were obtained after harvest. Return on investment (ROI) was determined from the records of the costs incurred and returns obtained from the sales of the compost.

Populations of nematodes, protozoa, bacteria and fungi were viewed under light microscopy with a magnification of 400x and identified based on their morphological structures. These were quantified as absent or present and either few or plenty. The data were analyzed using Analysis of Variance in Randomized Complete Block Design. Tukey's test was used to determine the significant differences among the treatment means.

Result

Table 1 shows that composting aerobically with LABS and EMAS and commercial probiotics as enhancers was very costly. These were significantly more expensive than vermicomposting and anaerobic composting. Anaerobic composting with commercial probiotics costs significantly lesser than others. Sales per treatment of composted cattle manure revealed highly significant differences among treatments. Treatment 5 (vermicompost) obtained the highest sales while T_2 (aerobic with LABS and EMAS) decomposition attained the least sales. Sales incurred in anaerobically decomposed dairy wastes using commercial probiotics and LABS and EMAS were found comparable, but these were significantly higher than those decomposed by aerobic means T_1 (aerobic with commercial probiotic) and T_2 (aerobic with LABS and EMAS). Vermicomposting method generated the highest income ($p<0.01$). Anaerobic composting with commercial probiotics and locally-made probiotics show comparable income generated which was significantly lesser than the aerobic methods. The dairy wastes that were decomposed in T_3 (anaerobic with commercial probiotic), T_4 (anaerobic with LABS and EMAS) and T_5 (vermicompost) had comparable Returns on Investment (ROI). T_2 (aerobic with LABS and EMAS) significantly incurred the lowest return on investment among other composting methods. T_1 (aerobic with commercial probiotic) had significantly higher ROI than T_2 (aerobic with LABS and EMAS) though significantly lower compared to T_3 (anaerobic with commercial probiotic), T4 (anaerobic with LABS and EMAS) and T5 (vermicompost).

Table 1. Costs, sales, income and return on investment of composted dairy cattle farm wastes using aerobic, anaerobic and vermicomposting methods, per 100kg farm waste.

Treatments	Cost (PhP)	Sales (PhP)	Income (PhP)	Return on Investment (%)
T_1 - Aerobic, Commercial probiotics	122.00^b	304.00^c	182.00^c	149.00^b
T_2 - Aerobic, LABS & EMAS	140.00^a	168.00^d	28.00^d	20.00^c
T_3 - Anaerobic, Commercial probiotics	58.00^e	485.00^b	427.00^b	736.35^a
T_4 - Anaerobic, LABS & EMAS	76.00^d	470.00^b	394.00^b	518.62^a
T_5 - Vermicompost	97.00^c	690.00^a	593.00^a	611.34^a
F-test	**	**	**	**
CV (%)	1.04	3.21	4.19	18.45

The different composting methods produced compost at varying lengths of time. The longer it takes for the dairy farm wastes to be composted, the lesser number of cycles it will make in a year and the less efficient the method will make in a year. Table 2 shows that vermicomposting method significantly yields more compost and T2 yields the least. Anaerobic composting methods with and without enhancers were comparable but were significantly higher than aerobic methods yet significantly lower than vermicomposting. Efficiency was determined by computing the yield in one cycle and how many times it will cycle in a year considering the period it takes to completes composting.

Table 2. Yield (kg) and efficiency (kg yr^{-1}) of dairy cattle wastes composted using aerobic, anaerobic and vermicomposting methods, per 100kg of dairy farm wastes.

Treatments	Yield (kg)	Efficiency (kg yr^{-1})
T_1 - Aerobic, Commercial probiotics	25.33^c	101.33^c
T_2 - Aerobic, LABS & EMAS	14.00^d	56.00^d
T_3 - Anaerobic, Commercial probiotics	32.33^b	129.33^b
T_4 - Anaerobic, LABS & EMAS	31.33^b	125.33^b
T_5 - Vermicompost	61.00^a	276.00^a
F-test	**	**
CV (%)	3.44	3.44

Efficiency was also affected by the yield per cycle where the lesser yield found with aerobic composting with LABS and EMAS consequently becomes least efficient. Table 2 shows that it is more efficient to use vermicomposting because it took only two months to complete decomposing the wastes and it took three months for the other methods.

Discussion

The higher costs incurred with vermicomposting and aerobic composting were attributed to the labor incurred in turning the composts every 10 days. Labor of personnel to turn these composts may cost high due to the nature of the work. However, farmers may opt to choose these two methods for several reasons. The farms do not have manure management so these wastes were accumulated to decompose aerobically beside the animal barns in the farms and personnel get accustomed to its odor. Others choose vermicomposting to produce vermicompost and earn from the sales of earthworms. In the study of Mirza *et al.* (2018) they found that medium-scale composting facilities can obtain profits with better quality compost that demands better market value. Accordingly, business-oriented private firms sell compost at a higher price and better quality to sustain the composting operation.

Sales incurred were highly dependent on the yield of compost and its price. In this study, the quality of the compost was not the determinant of the price per kilogram sold. Sales were significantly higher with vermicompost than others at the same price. Though, in all methods, it was noted that there is income generated. Anaerobic method is less laborious and less costly, and with its high yield per cycle, the return on investment was highest ($p>0.01$). This implies that costs incurred in composting can be compensated. Vermicomposting method is more laborious, though its yield and sales were high, the resulting ROI was lesser than with anaerobic method.

Table 2 indicating the yield of vermicompost is more maybe due to the presence of some important microbes that help the earthworms to act faster as noted by Biradar *et al.* (2005). There is faster decomposition of green waste with vermicomposting than with aerobic and non- aerobically processes that can be explained by the fragmentation of organic matter by earthworms, which increases the surface area of the organic matter and thereby increases the quantity of organic matter accessible to microorganisms and microbial enzymes according to Singh *et al.* (2013). Physically compared to anaerobic method, vermicompost-treated soil has better aeration, porosity, bulk density and water retention (Lim *et al.*, 2015), with the presence of the earthworms nothing is wasted in the compost resulting to a higher yield. The higher yield with anaerobic composting conforms with the observations of Roebuck (2022), that anaerobic organisms work best when there is a complete absence of oxygen contrary to aerobic compost. And the lesser yield of aerobic compost concurs with Cromell (2016) that the presence of air from the existing spaces and pores between bits of organic matter will lose its moisture and generally affects the yield.

Looking at the efficiency of the methods, it took longer to decompose with aerobic and anaerobic methods. It took only 60 days to decompose with an earthworm which was as efficient as anaerobic composting. This conforms with the findings of Lim *et al.* (2016) that vermicomposting system is more efficient with its nutrient profile being generally higher than in traditional compost. Ali *et al.* (2015) reviewed a study that provides a general overview of the viability of vermicomposting processes as an eco-friendly approach. The integrated approach of composting and vermicomposting processes provides better results. Further, to optimize the process of vermicomposting, co-digestion of organic wastes provides a better opportunity for both microorganisms and earthworms to convert the organic fraction of solid waste under controlled environmental conditions.

Vermicomposting is a more efficient method than aerobic compost. As explained by Bajsa *et al.* (2004) vermicomposting gives a higher-quality end product than composting aerobic and non-aerobically, probably due to the joint action of enzymatic and microbial activities that occur during the process.

The vermicomposting process is faster than traditional composting as the material passes through the earthworm gut, whereby the resulting earthworm castings are rich in microbial activity (Vermi Co., 2001). Compared to the traditional composting method, Atiyeh *et al.* (2001) found that vermicomposting results in mass reduction of wastes, shorter processing time, and high levels of humus with reduced phytotoxicity. In fact, a study reviewed that vermicompost is efficient since it contains readily available plant nutrients (Bejbaruah *et al.*, 2013), and it is considered as a good soil amendment (Shinde *et al.*, 2020). This study agrees with Vukovic *et al.* (2021) that vermicomposting is an eco-friendly process transforming wastes to nutrient-rich resources, addressing issues in bacterial communities, and heavy metal contents.

Conclusion

There are several methods of composting the dairy farm wastes apart from leaving them accumulated anywhere in the farms unutilized and causing environmental pollutions. Farmers may have an ROI of 518 to 736% with vermicomposting and anaerobic methods which are significantly higher than aerobic composting. Costs vary significantly with each method tested particularly the additional labor incurred with regular turning in vermicomposts. Sales and income earned are influenced by the costs, and it varies significantly from each method, with the least income and ROI noted if farmers will leave these wastes to decompose under aerobic condition even with the presence of indigenous enhancers.

Composting dairy farm wastes are most efficient with the use of earthworms (vermicomposting) producing the highest yield of microbe-rich compost in a shorter period of time. Composting anaerobically may be adopted with indigenous enhancers like Lactic Acid Bacteria Serum, Effective Microorganism Activated Solution but it will take a longer period to decompose, lesser number of cycles in a year and lesser income than vermicomposting. Keeping the manure and other wastes abandoned beside the farms, even with some probiotic enhancers is not as efficient as vermicomposting and anaerobic composting. It takes two months to decompose with earthworms while it takes three months to decompose with anaerobic and aerobic methods. Compost yield with vermicomposting was almost thrice the yield of the other methods, but the labor costs are higher without mechanization.

Recommendations

This study recommends that programmed turning of vermicompost beds may be mechanized to reduce labor, and increase income. Policy advocacy is also recommended to utilize dairy farm wastes in dairy farm to minimize environmental pollution that poses health hazards to people, animals, and the environment. Further studies on the quality of composts generated along with various other methods are recommended.

Abbreviation

Lactic Acid Bacteria serum (LABS)

Effective Microorganisms Activated Solution (EMAS)

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