JOURNAL of Biotechnology and Conservation in WALLACEA

Volume 02, Number 01, April 2022
Pages: 53 – 58
DOI: https://doi.org/10.35799/jbcw.v2i1.42729

e-ISSN: 2808-4268

Fertilizer from Organic Waste: A Case Study of Small-Scale Biogas Reactors

Susan Marlein Mambu*[1], Glanny M C Mangindaan[2], Agustina Monalisa Tangapo[1]
[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sam Ratulangi.
Jl. Kampus UNSRAT Manado, 95115, Indonesia.
[2]Depatment of Civil Engineering, Faculty of Engineering, Universitas Sam Ratulangi.
Jl. Kampus UNSRAT Manado, 95115, Indonesia.
*Corresponding author: susan.mambu@unsrat.ac.id

Abstract
Small-scale biogas technology has been used globally for decades, and the potential application is providing great alternative means for managing organic waste. A large amount of yard waste such as grass, leaves, and branches is produced, which is a problem that needs to be effectively solved. Composting is a sustainable organic waste management practice that converts organic waste into valuable products such as liquid organic fertilizer and biogas. This study aimed to develop a small-scale biogas project to evaluate the feasibility of implanting the composting technology for the management of organic waste and to obtain an end-product with a commercial value as liquid organic fertilizer. The result indicated that creating a small-scale biogas reactor is more cost-effective, and eco-friendly, and showed a suitable development of the composting process, presenting a sustainable waste treatment method into valuable products such as liquid organic fertilizer and biogas that manages potentially harmful organic wastes.
Keywords: *bioenergy; biogas reactor; organic waste; organic liquid fertilizer*

INTRODUCTION

For the fast-growing area of Manado City, which relies on only one landfill, named the final disposal site (TPA) Sumompo, the waste management challenge is enormous. In 2018, Manado is one of the major cities that produces 2,064 m^3 of waste per day, was given a title as one of the dirtiest major cities in Indonesia by the Ministry of Environment and Forestry (KLHK), due to the overcapacity of the TPA Sumompo. To reduce waste at Manado City, recycling efforts must be improved and organic recycling services must be provided. Large institutions such as universities can play a unique role in advancing more effective, large-scale waste management systems. Additionally, students, lecturers, and staff must be properly educated on waste management practices (Lasut *et al*., 2019).

Sam Ratulangi University (UNSRAT) is located in the rural setting of the Manado City, North Sulawesi, Indonesia, is to create an advanced waste management system, that appropriately deals with all types of waste, especially a large amount of yard waste such as grass, leaves, and branches is produced on campus in UNSRAT. Focusing on the relationship between sustainability education and campus implementations, this study aims to develop a waste management plan that would include recommendations for the collection and disposal of organic waste on the campus, and details about the recycling process through biogas technology. We achieved this goal by assessing the current organic waste management system at slaughterhouse (RPH) Bailang, Manado City, engaging with key stakeholders, projecting organic waste management needs, and developing a waste management plan for UNSRAT.

Improving soil fertility can be done by using an organic farming system. The application of organic fertilizers serves to increase the need for nutrients and improve physical, chemical,

and soil biology. Organic fertilizer can help improve the life of organisms in the soil because they utilize organic matter as nutrients needed by the organism. The use of organic fertilizers derived from nature can maintain environmental sustainability without reducing production. Organic farming is an environmentally friendly method because it can improve soil nutrients so that in its application organic farming is very well used to replace the use of chemical fertilizers. Based on the experimental results, using organic fertilizers had increased soil microbial activity, improves soil structure, helps control runoff and erosion, was also recommended for increasing plant growth (Mambu *et al*., 2018 ; Tangapo *et al*., 2018).

Leave waste is one type of organic waste produced from biological materials. Leave litter can be found all around the environment, such as UNSRAT campus environment which is overgrown by trees. Handling that has been done is to collect leaf litter until it piles up later burn it, this combustion process will pollute the air. Because the handling management of leaf waste is still less effective needs to be developed management of leaf waste so that it becomes a useful product through the process of composting. As is well known, most people don't use leaf litter as organic fertilizer. This is because the process of composting leaf litter through decomposer agents will naturally take a long time. Biogas technology is essentially the bio-digestion of any organic material which requires a longer decomposition time such as leaves under anaerobic conditions. Leaves waste makes an ideal feedstock for biogas production; it is readily biodegradable and is available in large amounts from point sources around UNSRAT Campus.

Biomass energy sources have several advantages, among others, is a source of energy that can be renewed (renewable) so that it can provide a sustainable source of energy (sustainable). In Indonesia, biomass is a source of very important natural resource with various products primary as fiber, wood, oil, food, and others which are not used to fulfill domestic needs are also exported and become bones the back of the country's foreign exchange earner. For biomass to be used as fuel, technology is needed to convert it. Biomass conversion technology of course requires differences in the tools used to convert biomass and produces a difference in the resulting fuel. One of them is biochemical conversion, which is a conversion technology that uses microbes to produce fuel. In simple terms, biomass gasification can be defined as the conversion process of cellulosic materials in a gasification reactor (gasifier) into fuel (Sriram and Srividhya, 2017).

Biogas is the mixture of gases produced by the microbial degradation of organic matter in the absence of oxygen called anaerobic digestion, primarily consisting of methane and carbon dioxide. Biogas can be produced from agricultural waste, food waste, manure, and other organic human waste. Through this anaerobic process which stabilizes organic waste in the absence of air and transforms it into biofertilizer and biogas. Organic waste such as leaves is biochemically degraded in highly controlled, oxygen-free conditions circumstances resulting in released gases react with each other in a chain of processes, and a separated liquid. There are lots of different designs of biogas reactor, where a biogas plant needs some methane-producing bacteria to get it started. This is found in animal dung named cow rumen, so a small amount is used to start the process, once the system is producing biogas, the bacteria reproduce and keep the process going. The process is the same as in a cow’s stomach, where the stomach bacteria convert food into a semi-solid material and biogas. The most common type of biogas plant is a Fixed Dome Biodigester, the same type we use in UNSRAT, where the design combines the slurry container and biogas container in a single chamber. As the slurry breaks down, it releases the gas, which rises to the top of the dome and can be piped away to a kitchen stove (UNEP, 2013).

A sustainable rural campus ecosystem is an important manifestation of environmental protection education in UNSRAT Campus. To meet its goal of zero waste, UNSRAT needs to develop a sustainable alternative to the current waste disposal practices. This study presents a

sustainable waste treatment method in converting the organic wastes (plant waste and cow rumen) produced within UNSRAT Campus into valuable products such as organic liquid fertilizer and biogas.

MATERIALS AND METHODS

The experimental study was conducted in a batch digester reactor of 60 liters capacity plastic drum at an ambient environmental condition. Before a normal operation, the biogas digester must be started This is done by preparing a 1:1 mixture of cow rumen and water then allowing this to ferment anaerobically for two weeks. The plant's materials were collected from the Faculty of Mathematics and Natural Sciences (FMIPA) and around the Sam Ratulangi University. After entering the rumen material, chopped leaves and water are also put into the biodigester, then monitoring activities for the development of gas production begin to be carried out. The most common type of biogas plant is a Fixed Dome Biodigester, the same type we use in UNSRAT, where the design combines the slurry container and biogas container in a single chamber. As the slurry breaks down, it releases the gas, which rises to the top of the dome and can be piped away to a kitchen stove (Fig. 1).

Figure 1: Small-Scale Biogas Reactor Project and Big-Scale Biogas Reactor Project at Sam Ratulangi University Manado

In this study, growth data of *Brassica rapa* L. was performed to evaluate effects of different POC levels as Anaerobic Digestion Effluent (ADE) by-product. The pot experiment was carried out in polybags capacity of 5 kg. This study used a Randomized Block Design with experimental treatments were as follows: without POC applied (control), covering 50 ml/L/polybag POC (AA), 75 ml/L/polybag POC (AB), 100 ml/L/polybag POC (AC), and 50 ml/L/polybag NASA POC (AD) with three replications. One-way analysis of variance (ANOVA) was used to analyze each *Brassica rapa* L growth parameter, and when ANOVA indicated a significant difference, mean comparisons were carried out using post-hoc Tukey multiple comparison tests. In all cases, $P < 0.05$ was considered significant.

RESULTS AND DISCUSSION

Liquid Organic Fertilizer

Liquid Organic Fertilizer (POC) is a liquid fertilizer made from organic materials. This fertilizer is made with a certain process, so it is available in liquid form (Fig. 2). The function of POC is as a provider of nutrients and serves as a complementary fertilizer. Since anaerobic

digestion through a biogas reactor only releases carbon to the gas phase, the other nutrients (nitrogen, phosphorus, and micronutrients) remain in the effluent, which makes it a high-quality liquid organic fertilizer and soil amendment.

Figure 2. Liquid Organic Fertilizer from Small-Scale Biogas Reactors Project

As a preliminary study, research was conducted on the growth of Caisim (*Brassica rapa* L.) planted in polybags with POC treatment and without POC treatment. Significantly, the initial growth of Caisim seeds with POC treatment showed better vegetative morphological characteristics than without POC treatment (Fig. 3). Although further research is needed, several previous studies have proven that the use of POC in vegetable crops has improved soil quality by increasing the nutrients in the soil (Masarimbi *et al*., 2010; Taberima *et al*., 2010).

Figure 3. Vegetative Growth Characteristics of Caisin Seed (1 Week After Sowing) with POC and without POC treatment

Biogas

Before a normal operation, the biogas digester must be "started" This is done by preparing a 1:1 mixture of cow rumen and water then allowing this to ferment anaerobically for several weeks. After entering the rumen material, chopped leaves and water are also put into the biodigester, then monitoring activities for the development of gas production began to be carried out as shown in Fig. 4, that the increase in gas volume was seen to change on the 4th day and after that, it continued to increase until it reached its peak on the 11th day. After the torrent reservoir is fully filled with gas, there is no change in the volume of gas.

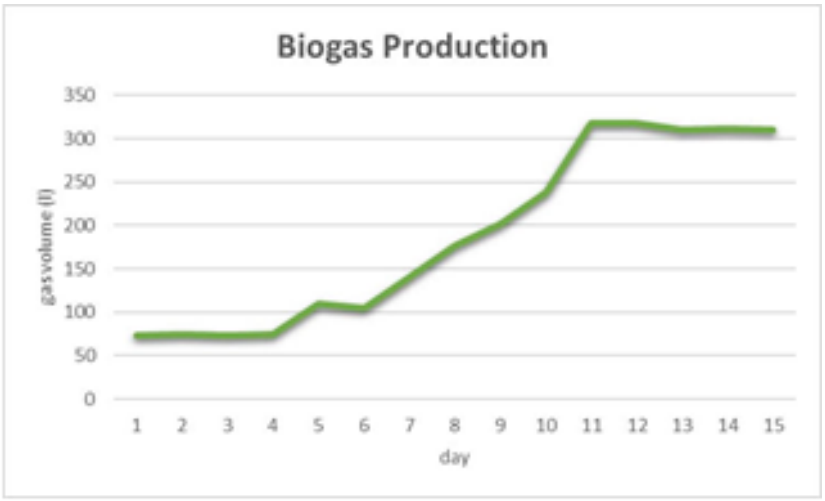

Figure 4. Small-Scale Biogas Production

The gas produced after it is full will be wasted in the air. Previous research Sanjaya *et al*. (2015) obtained the production of the lowest cumulative biogas stopped on the 16th day. Differences in biogas production are due to the availability of nutrients (source energy) for different anaerobic bacteria of each composition, so that impact the difference in the rate of fermentation of every composition.

CONCLUSION

Implementing a biogas reactor at the general public, the direct energy value of biogas may prove to be an even more significant asset in the future as natural gas prices have risen over the past few years and will likely continue this trend. As well as the university, students too can use the organic liquid fertilizer for their research, in the on-campus student organic garden, and for local gardeners and farmers could utilize the effluent as an organic liquid fertilizer in place of commercial fertilizers that are produced using less sustainable methods. By diverting the organic waste to a biogas reactor, a waste stream to the treatment plant will be removed, which will also reduce the costs associated with hauling organic waste from the treatment plant, and less solid waste would go to the landfill, providing savings in landfill tipping fees and trucking costs, as well as reducing energy use and carbon emissions associated with transporting solid waste. Importantly, applying this method in UNSRAT Campus represents a proactive showcase in Manado City where the campus can serve as the best practices venue for sustainable organic waste management.

REFERENCES

Lasut, A.Ch., Makalew, F.M., Opit, P.F. (2019). Manado City Waste Transportation Route Analysis With The Vehicle Routing Problem (VRP). Realtech Journal, Volume 15 (1), 7-12. https://scholar.google.com/citations?view_op=view_citation&hl=en&user=dOaynGUAAAAJ&citation_for_view=dOaynGUAAAAJ:9ZlFYXVOiuMC

Mambu S., Sugihara S., Kawame T., Nishigaki T., Toyota K., Miyamaru N., Tanaka H., Kanekatsu M. (2018). Effect of Green Manure Application on Soil Enzyme Activity and Nutrient Dynamics in a Sugarcane Field of Kitadaito, Okinawa, Japan. JARQ. 52 (4), 315-324. https://www.jstage.jst.go.jp/article/jarq/52/4/52_315/_pdf/-char/en

Masarirambi, M.T., Hlawe, M.M., Oseni, O.T., Sibiya, T.E. (2010). Effects of Organic

Fertilizers on Growth, Yield, Quality and Sensory Evaluation of Red Lettuce (Lactuca sativa L.) 'Veneza Roxa'. Agriculture and Biology Journal of North America, Volume 01 (06), 1319-1324. https://doi.org/10.5251/abjna.2010.1.6.1319.1324

Sanjaya, D., Haryanto, A., Tamrin. (2015). Biogas Production From A Mixture of Cow Manure with Chiken Manure. Jurnal Teknik Pertanian Lampung, Volume 04 (02), 127-136. https://jurnal.fp.unila.ac.id/index.php/JTP/article/view/827/756

Sriram, S., Srividhya, P.K. (2017). Technologies Involved in Biomass to Energy Conversion and Its Utilization in India. International Research Journal of Engineering and technology, Volume 04 (08), 1349-1353. https://r.search.yahoo.com/_ylt=AwrjZQa5zuFiM9gDro9XNyoA;_ylu=Y29sbwNncTEcG9zAzQEdnRpZAMEc2VjA3Ny/RV=2/RE=1658994489/RO=10/RU=https%3a%2f%fwww.irjet.net%2farchives%2fV4%2fi8%2fIRJETV4I8243.pdf/RK=2/RS=J0FBUyePWIS_0ppC.falTBGFPc-

Taberima, S., Prabawardani, S., Sarwom, R., Lyons, G. (2020). Organic fertilizer applications improve the growth of vegetable crops and chemical properties in the tailings deposition area at Timika, Papua, Indonesia. Nusantara bioscience, Volume 12 (02), 134-142. https://doi.org/10.13057/nusbiosci/n120208

Tangapo M.A., Astuti D.I., Aditiawati P. (2018). Dynamics and Diversity of Cultivable Rhizospheric and Endophytic Bacteria During The Growh Stages of Cilembu Sweet Potato (Ipomoea batatas L. var. cilembu). Agriculture and Natural Resources. Volume 52, 309-316. https://reader.elsevier.com/reader/sd/pii/S2452316X18300681?token=9D6EB80A49656C9F15CFCEC2C936072509D1BD78EDF81635D8CBEEAFE7DB62A99ACC63E1AC5556E9982D609681B80171&originRegion=eu-west-1&originCreation=20220728000204

United Nations Environmental Programme (UNEP). (2013). Reading Material Technologies for Converting Waste Agricultural Biomass to Energy. Available online at, http://www.mag.go.cr/proyectos/proy-residuos-agricolas-org/materiales/Technologies%20for%20convertin%20wab%20to%20energy.pdf, accessed on 13, August, 2021