



Chemical quality analysis of solid organic fertilizer produced by BUMDEs Bangun Mandiri Bekiung Village, Langkat Regency from empty fruit bunches and liquid waste from palm oil mills

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ABSTRACT

Organic fertilizer is fertilizer made from decomposed plant, animal, and human waste, produced from various types of organic materials with different properties and characteristics. Bekiung Village is one of the villages that cultivates oil palm plants. However, the utilization of oil palm waste, such as fibers, empty fruit bunches, and liquid waste from oil palm mills, is still limited or has not been effectively utilized by the community, which can cause negative impacts on the environment if left to degrade, while on the other hand, this waste has a high nutrient content. The Community Service Activity based on the Community Empowerment Scheme in the form of making solid organic fertilizer from empty fruit bunches and liquid waste from palm oil mills was carried out at BUMDEs Bangun Mandiri, Bekiung Village, Langkat Regency, in August 2024. The preparation of tools and materials consisted of 100 kg of empty palm fruit bunches, 200 kg of dried palm oil mill effluent, and a bioactivator. Next, the grinding process was carried out using a Hummer mill machine. The results obtained were an organic fertilizer capacity of ± 300 kg with a fermentation time of 21-35 days with a nitrogen content of 0.21% in the low category, P2O5 of 0.12% in the medium category, K2O of 1.09% in the high category, C -Organic at 2.30% in the low category, Ca at 1.57 me/100g in the medium category, Mg at 0.49 me/100g in the high category, pH at 6.34 in the neutral category, and KTK and moisture content at 15.20 me/100g and 10.28%, respectively.

Keyword: Waste, Bioactivator, Organic, Fertilizer, Weathering.

ABSTRAK

Pupuk organik merupakan pupuk yang berbahan dasar dari pelapukan sisa-sisa tanaman, hewan, dan manusia yang dibuat dari berbagai jenis bahan organik yang berbeda sifat dan karakteristiknya. Desa Bekiung merupakan salah satu desa yang membudidayakan tanaman kelapa sawit. Akan tetapi, pemanfaatan limbah kelapa sawit seperti, serabut, tandan kosong dan limbah cair pabrik kelapa sawit masih terbatas atau belum dimanfaatkan secara efektif oleh masyarakat, sehingga dapat menyebabkan dampak negatif terhadap lingkungan jika dibiarkan terdegradasi sedangkan di sisi lain limbah tersebut memiliki kadar hara yang tinggi. Kegiatan Pengabdian kepada Masyarakat Skema Pemberdayaan berbasis Masyarakat berupa pembuatan pupuk organik padat dari limbah tandan kosong dan limbah cair pabrik kelapa sawit telah dilaksanakan di BUMDEs Bangun Mandiri Desa Bekiung Kabupaten Langkat yang pada bulan Agustus tahun 2024. Persiapan alat dan bahan berupa limbah tandan kosong kelapa sawit 100kg, limbah cair kelapa sawit yang sudah dikeringkan sebanyak 200kg dan bioaktivator. Selanjutnya, dilakukan proses penghalusan menggunakan mesin Hummer mill. Hasil yang didapatkan adalah kapasitas pupuk organik yang dihasilkan ± 300 kg dengan waktu fermentasi 21–35 hari dengan kandungan nitrogen 0,21% dengan kategori rendah, P2O5 yaitu 0,12% dengan kategori sedang, K2O sebesar 1,09% dengan kategori tinggi, C-Organik sebesar 2,30% dengan kategori rendah, Ca sebesar 1,57 me/100g dengan kategori sedang, Mg sebesar 0,49 me/100g dengan kategori



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tinggi, pH sebesar 6,34 dengan kategori netral serta KTK dan kadar air yaitu 15,20 me/100g dan 10,28%.

Keyword: Limbah, Bioaktivator, Organik, Pupuk, Pelapukan.

1. Introduction

Bekiung Village is one of the villages in Kuala Subdistrict, Langkat Regency, North Sumatra Province, Indonesia. This village is located about 22 km Northwest of Medan City and about 11 km North of Binjai City. In general, the people of Bekiung Village work in agriculture and animal husbandry. The livestock commodities that are widely raised by farmers are cattle and goats, while the agricultural sector is dominated by oil palm plantations. The partner in this community service activity is BUMDes Bangun Mandiri, which acts as the manager of economic activities based on the village's local potential.

One of the efforts that can be made to overcome this problem is through the application of appropriate technology in processing palm oil and livestock waste into organic NPK fertilizer. The palm oil plantation and livestock businesses in Bekiung Village are quite developed, but the utilization of the waste produced is not yet optimal, even though this waste has great potential as a raw material for organic fertilizer that can support the sustainable availability of nutrients for plants.

Organic fertilizer is a fertilizer made from the decomposition of plant, animal, and human remains made from various types of organic materials with different properties and characteristics. Sources of organic materials include household organic waste and animal faces and urine (cows, goats, chickens or sheep). The remaining harvest from agricultural products such as rice straw, corn cobs, coconut Fiber, empty oil palm bunch ash, liquid waste from palm oil factories and cocoa shells can be used as raw materials for making organic fertilizer.

Organic fertilizers have an important role for soil, namely, they can improve the physical, chemical and biological properties of soil. Organic fertilizers can be produced easily and cheaply because only by utilizing agricultural waste as the basic material for making fertilizers. The use of agricultural waste for making organic fertilizers can also realize better agricultural management and support the improvement of land quality [1]. Some types of agricultural waste that are products of oil palm processing activities are palm fibber, empty bunches and factory liquid waste. The average fibber produced is 400g per fresh fruit bunch [2]. The yield of oil produced from unripe fruit is <20% while ripe fruit reaches 24-26% [3]. Harvesting overripe fresh fruit bunches increases the activity of lipase enzymes and increases free fatty acids, resulting in large amounts of palm oil mill effluent each year.

Bekiung Village is one of the villages that cultivates oil palm. However, the utilization of oil palm waste, such as fibers, empty fruit bunches, and liquid waste from oil palm mills, is still limited or has not been effectively utilized by the community. This can cause negative impacts on the environment if left to degrade, while on the other hand, this waste has a high nutrient content. Based on the conditions of the area and agricultural activities in Bekiung Village, the potential for palm oil waste production is estimated to be quite large. Each hectare of oil palm plantation can produce empty fruit bunches amounting to around 20–23% of the total fresh fruit bunches harvested, while cattle and goat farming activities produce daily organic waste in the form of livestock manure that has not been optimally utilized. The estimated amount of this waste indicates the availability of sustainable raw materials for the production of solid organic fertilizer. Empty palm bunches are waste from the palm oil processing process and palm oil liquid waste comes from liquid materials, such as boiling condensate, and calcium carbonate solution which is currently still limited in its use as organic fertilizer. According to the results of research, every ton of oil palm processed, there is waste generated, such as oil palm empty bunches by 23% or around 230 kg, oil palm shells by 6.5% or around 65 kg, palm mud by 4% or around 40 kg, fibbers by 13% or around 130 kg and liquid waste by 50% [4].

Oil palm empty fruit bunches have nutrients such as Nitrogen (N) by 1.5%, Phosphorus (P) by 0.5 Potassium (K) by 7.3% and Magnesium (Mg) by 0.9%, so that oil palm empty fruit bunches have the potential to be used as a basic ingredient in the production of solid organic fertilizer [5]. The content of N nutrients in the application area of palm oil liquid waste is 2.808% and without the application of palm oil liquid waste is

2.801%. Nutrient P in the application area of 0.165% is relatively the same as the area without application of palm oil liquid waste containing P 0.176% and nutrient K in the application area of 1.003% and without application of 0.953%. The C / N ratio value is classified as very high, so that in its utilization as organic fertilizer needs to be composted.

Covering material in making organic fertilizer plays a very important role in maintaining the temperature or temperature to remain stable in the heat generated. In addition, temperature is also important in the composting process because it indicates that the decomposer material containing the applied microorganisms is working actively. The speed of decomposition and the quality of solid organic fertilizer depend on the conditions that affect microb activity, one of which is the supply of oxygen, so the use of good cover material can affect the quality of the fertilizer produced [6].

The manufacture of solid organic fertilizer from empty fruit bunch waste and palm oil liquid waste at BUMDEs Bangun Mandiri Desa Bekiung Kabupaten Langkat with the help of the Community Service team of the University of North Sumatra is applied using the right combination of waste and processing. Therefore, it is necessary to analyze the chemical properties of solid organic fertilizers that have been produced by BUMDEs Bangun Mandiri Desa Bekiung Kabupaten Langkat which meet the standards of SNI 19-7030-2004.

This community service activity aims to improve the capacity of BUMDEs Bangun Mandiri partners in applying appropriate technology to the production process of solid organic NPK fertilizer made from empty fruit bunches and palm oil mill effluent. Specifically, this activity aims to evaluate the chemical quality of organic fertilizer produced by partners after the technology transfer process, as an indicator of the success of technology implementation and the level of partner independence in waste management. The results of the chemical quality evaluation are expected to form the basis for assessing the suitability of the organic fertilizer produced to support sustainable agricultural practices.

This community service activity is urgent in supporting the implementation of national research results related to the use of palm oil waste as organic fertilizer. The novelty of the service lies in a measurable technology transfer approach, in which BUMDEs partners are assisted until they are able to produce organic fertilizer independently. Chemical quality analysis is used as an evaluation tool for the service to ensure that the quality of the fertilizer produced is supported by the partners' ability to operate production equipment and manage production stages consistently, thereby strengthening the sustainability of community empowerment.

2. Methods

Community Service activities for the Community-based Empowerment Scheme year 2024 in the form of making solid organic fertilizer from empty bunch waste and palm oil mill liquid waste have been carried out at BUMDEs Bangun Mandiri Village Bekiung Langkat Regency which was carried out in August 2023.

Preparation of tools and materials in the form of 100kg palm empty fruit bunch waste, 200kg dried palm oil liquid waste and bio activator. Furthermore, the pulverization process is carried out using appropriate technology, namely, the Hummer mill machine (can be seen in Figure 1.) The ratio of materials used is 2: 1: 1 and incubated for 4 weeks. Chemical quality analysis (Temperature (°C), Nitrogen (%), P₂O₅ (%), K₂O (%), C -Organic (%), Ca (me/100g), Mg (me/100g), pH, Cation Exchange Capacity (CEC) (me/100g) and Moisture Content (%)) of organic fertilizer in this activity is not positioned as laboratory research, but rather as part of the evaluation of community service. Chemical quality parameters are used to assess the success of the appropriate technology application by partners in the independent production process of organic fertilizer. Thus, the quality of the fertilizer produced reflects the level of understanding, skills, and capacity of the partners after the technology transfer process.



Figure 1. Process of solid organic fertilizer production by BUMDEs Bangun Mandiri.

The increase in partner empowerment was analyzed using quantitative and qualitative descriptive approaches. Empowerment indicators included an increase in partners' knowledge and skills in operating appropriate technology, partners' ability to independently carry out the stages of organic fertilizer production, and the consistency of fertilizer production results after technology implementation. Data was obtained through surveys before and after the activity, direct observation during the production process, and documentation of organic fertilizer production results. Fertilizer production quality was analyzed using organic fertilizer chemical quality parameters, which were used as indicators of the successful application of technology and increased partner capacity.

3. Results and Discussion

Community service is carried out in Bekiung Village, Kuala District, Langkat Regency, North Sumatra Province, which is a strategic place for the development of organic fertilizers in both solid and liquid forms because it is located around a palm oil mill. In addition, BUMDEs members who are involved as partners also play an active role in making fertilizers on a small to large scale because this area has problems in managing palm oil waste.

The stages that must be carried out in making organic fertilizer from empty bunches and palm oil liquid waste are, namely, chopping empty bunches which aims to reduce the size of palm oil waste and expand the surface area of palm oil waste. This chopping is done using a chopping machine. Next, drying of palm oil mill effluent and inoculation with decomposers. In this process, 100 kg of shredded oil palm empty fruit bunches and dried liquid waste are put into a hummer mill machine, then 50 kg of dolomite and decomposer are added. After that, it was packed directly and incubated for 30 days as shown in Figure 1.

Community Service activities that have been completed are expected to have a positive impact on the community in Bekiung Village, Kuala District, Langkat Regency, especially in terms of additional income for the community in the village as an outcome activity. After completing the training in making organic fertilizer, the team conducted a survey to the community manually by distributing questionnaire paper about additional income before and after being able to make organic fertilizer independently. The following is a graph of the results of the survey to the community that has been carried out.

3.1 Community service activities outcome survey

Survey of Community Service activities on the outcome of activities against the community in BUMDEs Bangun Mandiri in Bekiung Village, Kuala District, Langkat Regency has been carried out directly with 40 participants so that the results are presented in Figure 2 below.

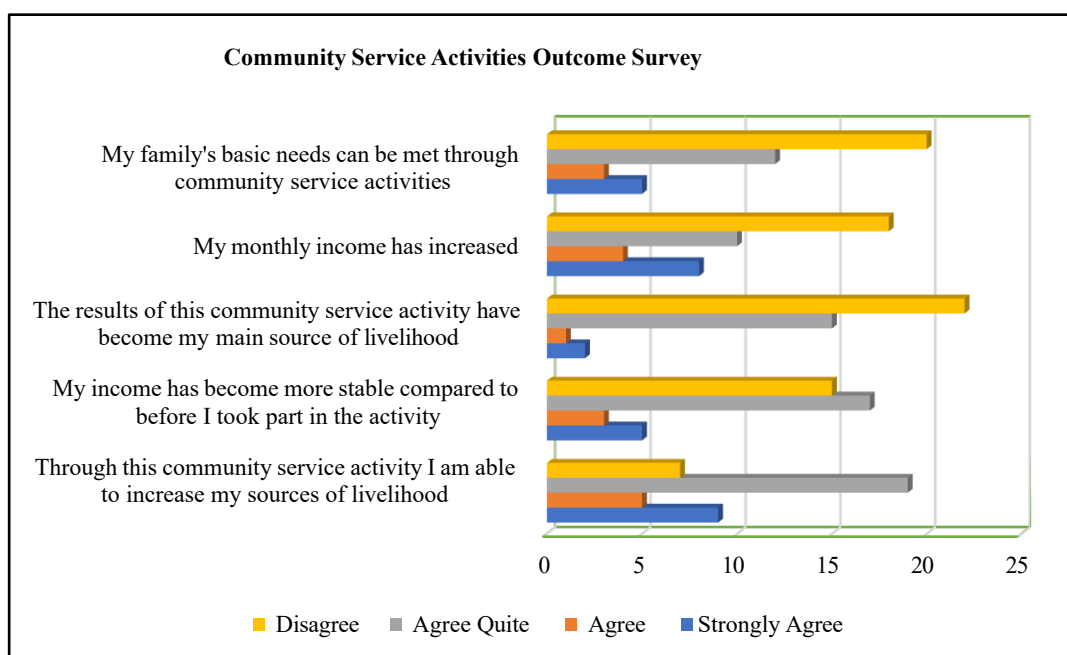


Figure 2. Diagram of survey results about the outcome of community service activities.

Based on Figure 2. above, the diagram of the survey results on the outcome of Community Service activities with five questions such as: whether through this community service activity I can increase my source of livelihood, whether my income has become more stable than before I participated in this activity, whether the results of this community service activity have become my main source of livelihood, whether my monthly income has increased and whether my family's basic needs can be met through community service activities with four answer options namely disagree, disagree, agree and strongly agree. The results obtained from the survey were that most of the five questions answered disagree and disagree and some people answered agree and strongly agree. This means that people in the village have a main livelihood as an outcome for survival. However, the organic fertilizer products that have been made can be an additional income for these farmers and can also reduce expenses for fertilizers on their cultivated plants.

Before the program, partners did not earn any income from organic fertilizer and spent ±Rp1,200,000–Rp1,500,000 per cycle on synthetic fertilizer. After the program was implemented, partners were able to produce ±300 kg of organic fertilizer per cycle, earn additional income of ±Rp900,000, and reduce fertilizer expenses by ±60%, supported by the partners' ability to manage production independently.

3.2 Organic fertilizer temperature

Temperature plays an important role in providing information about the activity of microorganisms during the composting process. Temperature measurements are taken every day using a thermometer with units of degrees Celsius (°C). Temperature indicates changes in microorganism activity in decomposing organic matter. Compost temperature data obtained during 30 days of composting can also describe the composting stages as presented in Figure 3.

Based on Figure 3. obtained the results of temperature changes in the graph observed every day for 30 days after incubation. In the reactor produced with the composition of empty fruit bunch organic fertilizer and palm oil mill effluent, the temperature continued to increase from the first day to day 19, namely 28 °C to 31 °C and the maximum temperature reached 33 °C on the 20th day. This is the stage where the microbes contained in the compost raw materials have adapted, proliferated and are reaching the peak in the composting process. Then on the 21st day until the 30th day, the temperature showed a gradual decrease, which ranged from 31°C to 28°C. The decrease is caused by decreased microbial activity in breaking down the levels of available organic matter and shows that the compost has entered the maturity phase. The category of mature compost is when the compost temperature is the same as the groundwater temperature (28°C to 30°C) [7].

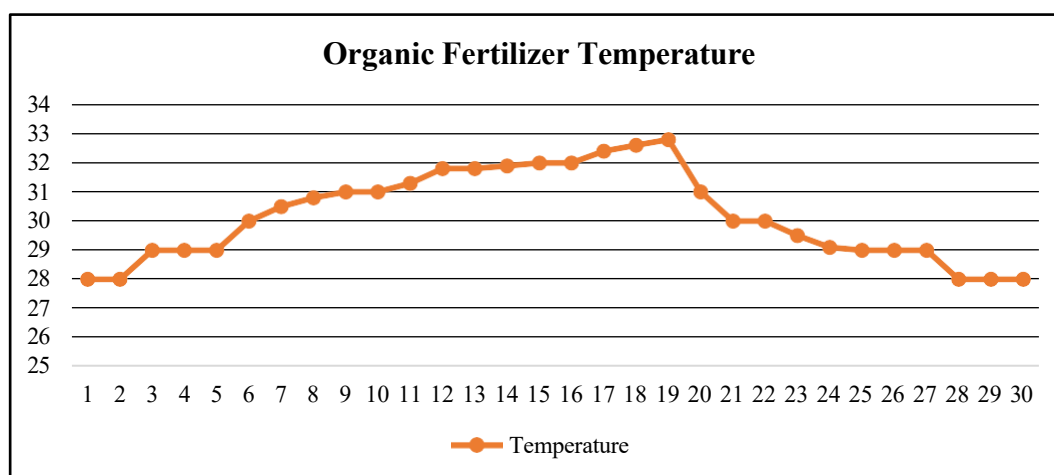


Figure 3. Temperature graph of organic fertilizer.

3.3 Chemical quality analysis of organic fertilizer produced

The chemical characteristics of organic fertilizer derived from mill waste and oil palm empty fruit bunches observed were Nitrogen, P₂O₅, K₂O, C-Organic, Ca, Mg, pH, CEC and moisture content. The determination of organic fertilizer characteristics was carried out at the end of the fermentation process according to the respective test methods and compared with SNI 19-7030-2004. Data on the chemical characteristics of organic fertilizer are presented in Table 1.

Table 1. Chemical quality analysis results of solid organic fertilizer from empty fruit bunches and palm oil mill liquid waste.

No.	Parameters	Methods	Analysis Result	Category	SNI 19-7030-2004
1	Nitrogen (%)	Volumetry	0.21	Low	Min 0.40
2	P ₂ O ₅ (%)	Spectrophotometry	0.12	Medium	Min 0.10
3	K ₂ O (%)	AAS	1.09	High	Min 0.20
4	C-Organic (%)	Gravimetry	2.30	Low	27-28
5	Ca (me/100g)	AAS	1.57	Medium	Max 25.50
6	Mg (me/100g)	AAS	0.49	High	Max 0.60
7	pH	Potentiometer	6.34	Neutral	6.80-7.49
8	Cation Exchange Capacity (me/100g)	Volumetry	15.20	-	-
9	Water Content (%)	Oven	10.28	-	Max 50

Based on Table 1, obtained the results of chemical analysis of organic fertilizers made with the community in Bekiung Village with BUMDes Bangun Mandiri partners, namely characters with high categories based on SNI 19-7030-2004 are in the character of the percentage of Potassium Oxide (K₂O) and Magnesium (Mg), namely 1.09% and 0.49%. It is known that the element Magnesium is absorbed by plants in the form of Mg²⁺ ions which are an important element in plants as a constituent of chlorophyll. Magnesium also has an important role in nitrogen metabolism. The higher the plant absorbs Mg, the higher the protein content in the roots or the top of the plant. Furthermore, characters with moderate category are found in the characteristics of phosphorus and calcium, which are 0.12% and 1.57 me/100g. Then, in the category of nitrogen and C-Organic characteristics, namely 0.21% and 2.30%. Furthermore, the resulting pH character is a neutral category of 6.34. The resulting characters in the medium to low category may be due to the ratio of organic fertilizer base material that is not suitable so that it still needs to be evaluated until the appropriate results are obtained.

The production capacity of solid organic fertilizer produced by the partner of BUMDes Bangun Mandiri in one production cycle is ±300 kg, with a fermentation time of 21–35 days. This capacity was achieved after the application of appropriate technology and supported by the partner's ability to operate production equipment and manage the production stages independently.

The quality of organic fertilizer produced is inseparable from the improvement in partners' ability to operate production equipment (PE) introduced through community service activities. Assistance in the use of equipment such as hammer mills, conveyors, and simple sieves enables partners to produce raw materials with a higher level of fineness and homogeneity, thereby supporting a more optimal fermentation process. The partners' ability to independently manage the production stages, from raw material processing to packaging, shows that the quality of the fertilizer produced is a direct result of the partners' increased capacity and mastery of the PE following the technology transfer process.

The chemical quality parameters of organic fertilizers indicates that partners are able to consistently implement fertilizer production stages, reflecting an increase in capacity and empowerment of partners after technology transfer. The quality of the organic fertilizer produced shows that partners not only understand the training material, but are also able to consistently apply the technology, which is a key indicator of the success of community empowerment services.

4. Conclusions

This community service activity shows that the quality of NPK solid organic fertilizer can be improved after applying the right technology, supported by increased empowerment of partners. Increased empowerment of partners is measured based on their ability to operate production equipment, carry out the stages of fertilizer production independently, and ensure that the chemical quality of the fertilizer produced remains consistent. The results of the chemical quality analysis of organic fertilizer are used as an indicator of service evaluation to ensure that partners are able to produce fertilizer that is suitable for application.

Thus, the quality of the fertilizer produced not only reflects the success of the technical process, but also serves as measurable evidence of the increased capacity and independence of partners as the main results of community empowerment activities. In addition, this activity also shows that the quality of solid NPK organic fertilizer can be achieved after applying the right technology, supported by the ability of BUMDes Bangun Mandiri partners to operate production equipment and carry out the production process independently. The economic impact of this activity can be measured, as partners are able to produce approximately ± 300 kg of organic fertilizer per production cycle, which can reduce the cost of purchasing synthetic fertilizer by $\pm 60\%$ compared to conditions before the program. These quality achievements and economic benefits show that community service activities not only increase the capacity and independence of partners, but also make a real contribution to cost efficiency and increased income as the main results of community empowerment.

5. Acknowledgment

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