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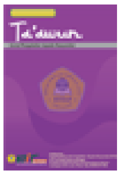

INNOVATION IN THE USE OF ORGANIC WASTE FOR BIOBATTERY AND BIOGAS PRODUCTION AT TPS3R LAMONGAN

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Abstrak

Sampah organik yang menumpuk di lingkungan Tempat Pengolahan Sampah 3R (TPS3R) sangat perlu dimanfaatkan sebaik mungkin. Tujuan dari kegiatan pengabdian ini adalah pemanfaatan energi dari sampah organik sebagai bahan baku utama pembuatan biobaterai dan biogas. Hasil akhir dari pengabdian ini yaitu berupa alat yang bisa mengkonversi energi dari sampah organik ke listrik (biobaterai) sekaligus sebagai pembuatan gas (biogas). Metode pengabdian menggunakan cara sosialisasi dan workshop penerapan teknologi dengan cara merangkai alat dan bahan. Peralatan Biobaterai dan biogas jika beroperasi setiap harinya mampu menambah pemanfaatan sampah organik sebanyak 17 kg, dengan 5 kg untuk biobaterai dan 12 kg untuk biogas. Sel biobaterai yang berisi sekitar 100 mL sampah organik mampu menghasilkan tegangan maksimal 0,9 Volt dan arus listrik maksimal 6 mA. Biogas sendiri membutuhkan proses pemilahan dan proses fermentasi yang waktunya disesuaikan dengan ada tidaknya stok sampah organik di TPS3R. Tempat Biogas (Digester) awal pemakaian membutuhkan sampah organik sebanyak 600 kg. Karya pengabdian ini diharapkan mampu menginspirasi masyarakat, terutama untuk Tim TPS3R Sekar Manfaat Sekaran Lamongan dalam mengelola sampah di sekitarnya dengan lebih baik.

***Kata kunci**: Biobaterai; Biogas; Organik; Sampah; TPS3R*

Abstract

Organic waste that accumulates in the 3R Waste Processing Site (TPS3R) environment needs to be utilized as well as possible. The purpose of this community service activity is to utilize energy from organic waste as the main raw material for making biobattery and biogas. The final result of this community service is a tool that can convert energy from organic waste to electricity (biobattery) and produce gas (biogas). The community service method uses socialization and technology application workshops by assembling tools and materials. Biobattery and biogas equipment, if operated every day, can increase the utilization of organic waste by 17 kg, with 5 kg for biobattery and 12 kg for biogas. Biobattery cells containing around 100 mL of organic waste can produce a maximum voltage of 0.9 Volts and a maximum electric current of 6 mA. Biogas itself requires a sorting process and a fermentation process whose time is adjusted to the presence or absence of organic waste stock at TPS3R. The initial Biogas Place (Digester) requires 600 kg of organic waste. This community service work is expected to inspire the community, especially the Sekar Manfaat Sekaran Lamongan TPS3R Team, to better manage the waste in their surroundings.

Keywords: Biobattery; Biogas; Organic; Waste; TPS3R

INTRODUCTION

One of the sources that is targeted for the use of new and renewable alternative energy is organic waste (Apriyanthi et al., 2024). Organic waste, one of its uses, can be used as a source of electricity energy (Sari, 2021). Energy sources derived from petroleum and coal are not environmentally friendly. This energy is the cause of air pollution and takes thousands of years to be reused (Gifron et al., 2018). In general, the community still lacks concern for the waste problem, especially in the processing process (Putri et al., 2023). As a result, the accumulation of waste continues to increase, both in the domestic environment and at the final processing site (Damayanti et al., 2021).

This has led to the expansion of the land where the final processing is carried out without efforts to solve the waste problem wisely (Maharja et al., 2022). An uncontrolled increase in the amount of waste will harm the community, with the emergence of various sources of disease and potential natural disasters, such as floods, landslides, water pollution, and other threats (Panjaitan et al., 2024). According to Khamil et al., (2023), If not managed and processed properly, this waste can cause problems, such as environmental pollution, social impacts, health issues, and cultural disturbances. So it is very necessary to be able to utilize organic waste at TPS3R Sekar Benefit, to reduce the volume of waste as well as be useful for TPS3R and the surrounding community (Wahyuni et al., 2022).

TPS3R Sekar Benefit as a target partner is located in Sekaran Village, Sekaran District, Lamongan, which aims to deal with waste problems. Sekaran Village is a village located about 25 kilometers from the center of Lamongan City. In 2019, the population of Sekaran Village, which reached 6,983 people, produced 600 kg/day of organic and inorganic waste. TPS3R's vision is to make Sekaran Village a Waste Independent Village by 2025, in line with one of the goals carried out by the village government. It is hoped that Sekaran Village will be able to manage and process waste produced by its own community (Wahyuni et al., 2022).

The amount of waste collected in Lamongan Regency can reach 2,147.63 m3 every day. The dominant composition of waste in Lamongan Regency is organic waste, which is 53.95%, the rest consists of plastic, wood, paper, metal and so on (Fadeli., 2017). This large amount of organic waste, if not managed properly, will pollute the environment. So it is very necessary to take action for the processing or utilization of this organic waste. The service by utilizing organic waste into biobatteries and biogas was carried out for the first time at TPS3R Sekar Benefit Sekaran. In the future, TPS3R will be used as an educational place, biobatteries and biogas can become icons. TPS3R will also be an interesting place for the community to manage waste to be more useful and environmentally friendly (Beritasiber, 2024). This service is also in line with the regulation of the Lamongan Regent number 23 of 2015, related to investment in the development of renewable energy, one of which can come from organic waste.

Wahyuni et al., (2022) has optimized waste by digitizing waste banks through the E-TPS3R Android application. TPS3R Sekar Benefit has also innovated to reduce the accumulation of organic waste by collaborating with UNISLA. The technological innovation carried out is integrated waste processing with maggots (Wakidah, 2022). Maggot is indeed able to reduce organic waste, but its effectiveness is more to fruit and vegetable waste only so that other organic waste cannot be handled properly (Dewi & Sylvia, 2022). The use of maggot and fertilizer produced is not proportional to the amount of waste in TPS3R. Even organic fertilizers used by farmers have also decreased. As a result, the waste that has been processed is finally disposed of back to the Final Shelter.

One alternative that can be developed as a replacement for conventional batteries is biobatteries. According to Fadlillah, (2015), dan Yurnalisdel, (2023), Battery waste is commonly known as B3 waste, which stands for Toxic and Hazardous Materials. This type of waste, if not managed properly, can result in significant damage to the environment. Kholidah, (2015), said that some fruits can produce electrical energy. Research that has successfully used waste such as vegetables, marigold flowers, star fruit, Akashmoni leaves, and Hashtag flowers has been conducted. The results showed that by using Zn-C electrode pairs, star fruit extraction gave the best results, which produced a voltage of 11.06 V and a current of 26.74 mA from ten voltaic cells (Nath, 2015).

Biobatteries are a source of electrical energy produced from organic materials (Dalimunthe et al., 2024). Unused fruit waste can be processed into products that contribute to environmental sustainability, such as turning them into biobatteries (Hotang et al., 2018). Biobatteries or voltaic cells are electrochemical cells that function to convert chemical reactions into electrical energy. According to Lestari, (2023), Batteries can produce electrical energy through a chemical process by involving the transfer of electrons through a conductive medium to produce electric current and potential differences. According to Fatimah et al., (2023), Chemical reactions in volta or galvanized occur spontaneously. A voltaic cell is made up of two main components, namely the anode (-) and the cathode (+).

This biobattery produces electricity through the use of renewable fuels that contain glucose, sucrose, fructose, and other compounds (Sarah et al., 2024). Then these ions are the determinants of the properties of electrical conduction and the physical properties of the electrolyte (Saputra et al., 2023). According to Rifanti et al. (2019), electric currents arise due to potential differences at both ends of the conductor or electrode, which encourages the movement of electrons from one place to another.

Organic waste can also be used as the main material for making biogas (Pamungkas et al., 2024). Biogas is a type of flammable gas. This biogas is produced through the fermentation process of organic matter carried out by anaerobic bacteria. The production of biogas occurs due to the decomposition of organic matter under anaerobic conditions, which produces gas (Syahfitri et al., 2024). This decomposition process is supported by a variety of microorganisms, with methane-producing bacteria as the main contributor. The gas produced is mostly methane (CH4) and carbon dioxide (CO2) gas. This methane gas is used for combustion or stoves (Megawati, 2015).

The purpose of the service activity is the use of organic waste for the manufacture of biobatteries and biogas. The first result of this service is the acquisition of a tool that can convert energy from organic waste to electricity (biobattery). The second result is that organic waste is the main raw material for the production of biogas (Thermal Energy). The results of this service are expected to be used by the community, especially for TPS3R Sekar Benefit Sekaran Lamongan. The hope is that people can get clean and affordable energy. The surrounding community can also live in a healthy and prosperous environment by better utilizing and managing the waste around them. Reducing the volume of organic waste can reduce the problem of environmental pollution.

MATERIALS AND METHODS

The implementation of this community service program was carried out for six months at TPS3R Sekar Benefit Sekaran in Lamongan to apply biobatteries and biogas equipment by utilizing the main material, namely organic waste. The tool will be available and ready to use following the requirements of Community Service as follows:

Socialization Stages

This socialization was aimed at the "TPS3R Sekar Benefit" Sekaran and the surrounding community in Sekaran District, Lamongan. This socialization is related to Organic Waste based on its type or type, as well as its use as biobatteries and biogas.

Training Stages

This training stage is carried out by explaining the manufacturing method, assembling tools and materials, and determining good conditions for the manufacture of biobatteries and biogas.

Stages of Technology Application

The application of technology used in Sekaran's "TPS3R Sekar Benefit" is energy conversion. The main problem is focused on the use of organic waste that has not been maximized. Organic waste stores chemical energy that can be converted into electricity and heat. The main reference in this stage that will be conveyed is related to the type of waste and how to use energy conversion technology in the form of biobatteries and biogas. The research on biobatteries and biogas used as a reference comes from independent research and by others nationally and internationally.

Stages of Assistance

Assistance is carried out from the first day of service until later if biobattery and biogas equipment experience problems that cannot be solved by the "TPS3R Sekar Benefit" itself. Biobatteries according to the method can be checked periodically once a week to find out whether there is still a current produced. Biogas is also checked periodically to avoid gas and sludge leaks. Later it can also be printed/given a guidebook or SOP for the maintenance and safety of biobatteries and biogas.

Evaluation

The evaluation is carried out at the end of the activity by distributing the evaluation form to TPS3R, the community, or village officials. The purpose of this evaluation is to consider improving the scheme that has been carried out, as well as for the theme of further service/research, especially in the field of biobattery/biogas.

Program Sustainability

This service is expected to be able to provide a real picture to the community, especially to the TPS3R team in managing organic waste. Organic waste is the main material that can be used as an electrolyte for biobatteries and biogas. The "TPS3R Sekar Benefit" itself or the surrounding community is expected to increase the quantity and quality of biobatteries and biogas following the direction of the Community Service Team of Billfath University. Quantity and quality can also be a source for further research in maximizing the potential of organic waste as a raw source of biobatteries and biogas. This service can also be extended to the surrounding community, especially those that have abundant organic waste, such as goat or cattle farms.

Partners of "TPS3R Sekar Benefit" under the auspices of BUMdes Sekaran, contribute to providing a place for socialization, namely at the Sekaran village hall, Lamongan. In addition, Sekaran's "TPS3R Sekar Benefit" partner contributes to the preparation of electrolyte and biogas materials, namely organic waste. Organic waste will be sorted first from non-organic mixtures such as plastic or metal. This sorting is intended so that later organic waste can be used properly for the manufacture of biobatteries and biogas. The tools and materials for the manufacture of volta cells or Biobatteries are as follows: 5 kg of organic waste, voltmeter, ammeter, pH sensor (addition), humidity sensor (additional), crocodile clips, cables, electrolyte containers as many as 40 pieces, zinc as many as 20 plates, copper as many as 20 plates.

The stages of volta cell assembly are as follows: 1) Prepare the tools and materials needed in the assembly of the volta cell. 2) Performance check on one volta cell by taking data at 5 different points but still in one cell. 3) After success, then create a series of several voltaic cells in series and parallel. This stage is carried out 2 times of checking on each voltage cell circuit. 4) The voltage cell circuit is checked after 1 week, if there is no current, it is necessary to check the electrodes and electrolytes. 5) The Volta Cell circuit is ready to use and continues to recheck which is done once a week.

The second part of this service is the production of biogas. The tools and materials used in this second stage are as follows: reactor, inlet, outlet, pressure safety tube, stirring system, gas line, gas storage tank, stove, manometer (additional), thermometer (additional), bucket, shovel. An illustration of the manufacture of a biogas reactor is illustrated in Figure 1.

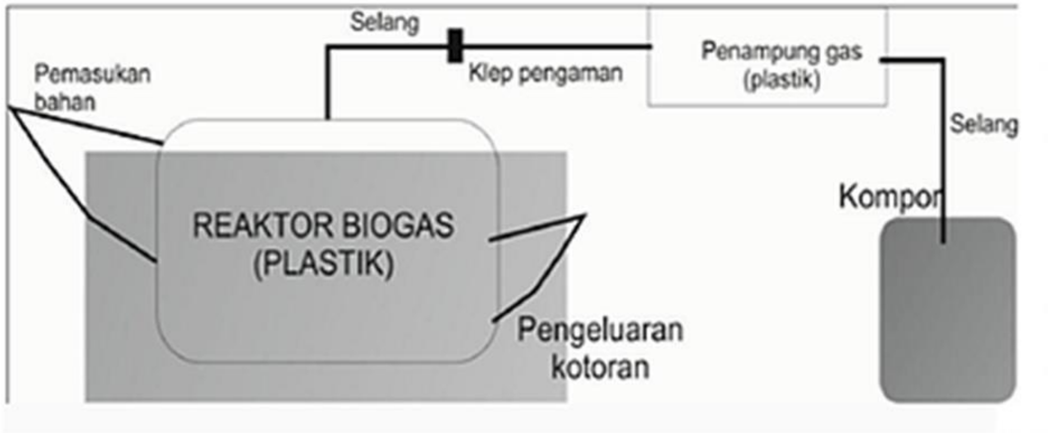

Figure 1. Biogas Reactor Manufacturing Scheme

After assembling the Reactor Reservoir (Digester), gas line, and stove according to the scheme, the next stage in making biogas from organic waste is: 1) Organic waste and water are mixed in a bucket with a ratio of one to one. The organic waste used is clean from plastic or stone mixtures. 2) Biogas materials from organic waste are put into a digester with a maximum of 1,200 liters. This volume is according to the volume of the digester reservoir used. 3) The fermentation time is approximately 10 days. The biogas reactor or digester and biogas reservoir will be seen condensing and hardening due to the biogas produced. If you use a manometer and thermometer, you will see the pressure and temperature increase. When the pressure increases, biogas can be used as fuel or immediately turn on the stove. If the pressure drops, immediately turn off the stove. 4) The biogas reactor is shaken occasionally so that the decomposition becomes perfect and the gas formed at the bottom of the digester can rise to the top. Stirring can also be done on each filling of the digester. 5) If the gas produced is not used, then the digester can be filled when it is going to be used only. 6) Digester maintenance and safety must be carried out daily or scheduled, to avoid gas or sludge leakage into the environment.

Organic waste can be filled every day, with a volume of approximately 12 liters. A total of 6 liters in the morning and 6 liters in the afternoon. The rest of the processing results of biogas materials in the form of *sludge* can be used directly as organic fertilizer. Mud can be used in wet or dry conditions.

RESULTS AND DISCUSSION

The first activity carried out was socialization of the use of organic waste for biobatteries and biogas. This activity was carried out to provide understanding to the community, the Sekar Benefit TPS3R team, and village officials related to biobatteries and biogas. This initial socialization is mainly aimed at the TPS3R Team so that later they will be able to assemble biobattery and biogas equipment independently. Socialization of the manufacture of biobatteries and biogas was carried out at the Sekaran village hall.

The participants who attended were quite enthusiastic in participating and at the same time asking questions related to biobatteries and biogas. The obstacles encountered in this socialization are the provision of tools, materials, and land for making biobatteries/biogas. Documentation of socialization activities in Figure 2. For tools and materials, there will be collaboration with the TPS3R TEAM in finding a place to buy and transport. The place of manufacture, temporarily placed in the TPS3R environment, will later be moved if used for other purposes. This socialization also displays data from previous research which is used as a reference for the use of organic waste around TPS3R.

Figure 2. Socialization and FGD on the Utilization of Organic Waste as Biobatteries, Biogas, and FGD Materials.

The data used for this service comes from various sources of organic waste that are commonly found around the Sekaran Lamongan Market, the data is explained in table 1.

Table 1. Electrical Data of various Organic Waste (Fruits and Vegetables)

No	Types of Fruits and Vegetables	V (V)	I (mA)
1	Purple Eggplant	0,62	0,25
2	Chinese Cabbage	0,43	0,10
3	Long Beans	0,62	0,43
4	Mango Fruit	0,88	2,83
5	Dragon Fruit	0,67	0,32
6	Water spinach	0,62	1,40
7	Spinach	0,57	1,08
8	Mustard greens	0,65	0,88
9	Cabbage	0,6	0,72
10	White eggplant	0,6	0,08

The data in Table 1 shows that chicory produces the lowest voltage of 0.43 Volts and the lowest current of 0.10 mA. Mangoes are able to produce the largest current and voltage, which are 0.88 Volts and 2.83 mA. If the fruits and vegetables above are assumed to be garbage that has been thrown in the trash, then these fruits and vegetables are likely to be mixed with each other. So from the data of the table above, the average value is taken, namely an average voltage value of 0.626 Volt and an average current of 0.809 mA. This data is enough to give participants an idea that organic waste from fruits and vegetables can produce electricity. Another discussion regarding biobatteries is their durability. According to research Fadli et al., (2012) that the durability of biobatteries can depend on the contact of the electrolyte with the electrode, and does not depend on the area of the electrode, the distance of the electrode, and the volume of the electrolyte.

Regarding biogas, several participants asked how safe and how much organic waste is needed for biogas production. The amount of waste that can be converted into gas depends on the methane content, or depending on where the organic waste comes from. Biogas technology is one of the Appropriate Technologies (TTG) that promises to achieve sustainable energy without damaging the environment, especially if it is produced through the anaerobic degradation (AD) process. The resulting biogas contains approximately 50–75% methane, 25–50% carbon dioxide, 0–10% nitrogen, 0–3% hydrogen sulfide, 0–1% hydrogen, and various other types of gases (Domrongpokkaphan et al., 2021).

The second activity is training in making biobatteries and biogas. This activity was attended by the Sekar Benefit TPS3R Team, the TPS3R Field Team, and the Community Service Team of Billfath University as speakers on biobatteries and biogas. Assisted by two billfath students for taking documentation in Figure 3.

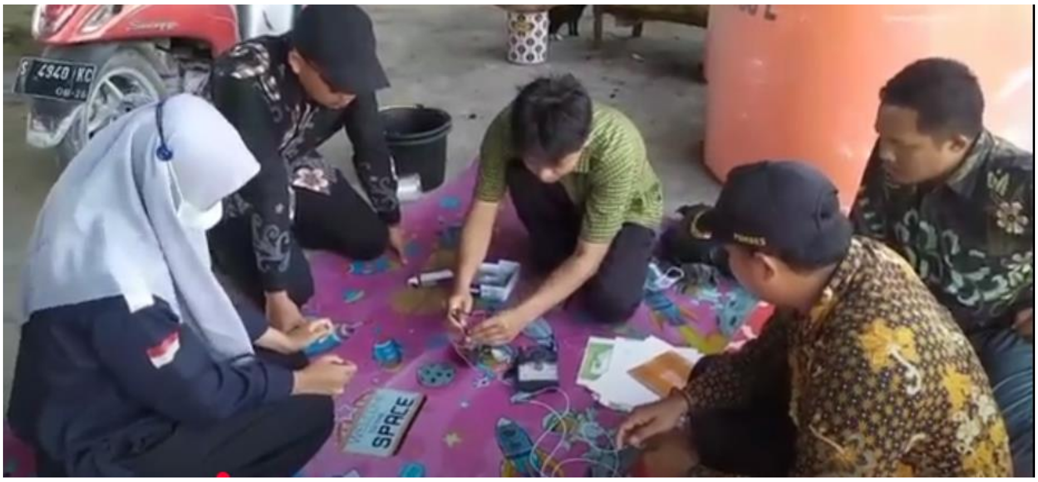

Figure 3. Biobattery Manufacturing Training Activities
Source: (beritasiber.com)

Research related to the use of organic waste conducted by Fadli et al., (2022) showed that soil mixed with organic waste could produce an average voltage of 0.635 Volts in a single voltaic or galvanic cell. In addition, the current produced reaches 0.185 mA. Interestingly, the power produced from these cells can be increased by the addition of chitosan derived from crab waste. According to Saputra et al., (2023), The use of chitosan from crab waste is able to increase the conductivity from 0.01 mS to 0.97 mS, the increase in conductivity can increase the current generated by the biobattery.

Prihatno et al., (2021), said that a conductivitymeter is a tool used to measure electrical conductivity, which aims to identify the ability of ions in water to conduct electricity. In addition, this measurement can also help predict the mineral content contained in water. Voltage cells or biobattery cells can be assembled in series and parallel. This merger or series of cells is intended so that the current is not too small (Chou et al., 2016). The results of the training on making biobatteries in the field show quite positive things, because the data shows better results than the reference of research data on fruit and vegetable waste (Fitrya et al., 2023). The voltage generated by each biobattery cell ranges from 0.6 Volts to 0.9 Volts. The electrical current of each biobattery cell ranges from 1 mA to 6 mA. The addition of waste from crabs to increase voltage and current awaits the existence of crab organic waste from the sekaran market.

The second activity related to biogas is constrained by organic waste that has not been sorted by automatic shredders and only leaves a small amount so that it cannot be used for biogas production. Most of the organic waste in TPS3R is waste from fruits and vegetables that come from markets and households in the Sekaran area. The amount of organic waste in TPS3R processed by the machine is uncertain. So the initial stage that can be done first is to assemble biogas tools. The biogas equipment set up was carried out in accordance with the scheme from the brochure provided by the Billfath University Service Team. The biogas scheme is in accordance with the service method. When performing the biogas device assembly documented in Figure 4. The TPS3R Sekar Benefit team understands it quite well. Later, it is only a matter of waiting for the organic waste to be sorted and adjusted to the maximum volume that can be filled in the digester reservoir. The initial stage of biogas production requires 600 kg of organic waste, which is adjusted to the initial volume of the digester reservoir, which is 1200 liters.

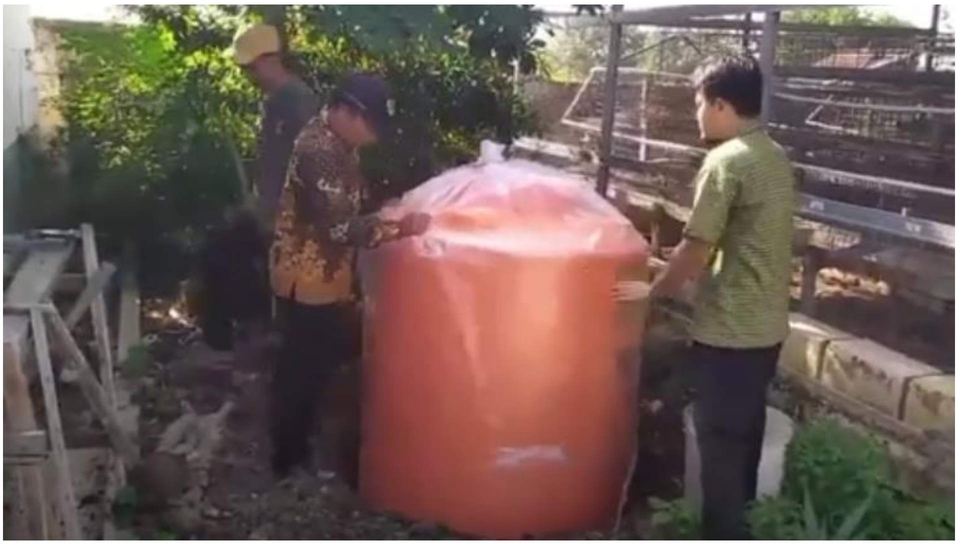

Figure 4. Biogas Initial Installation

Training activities as well as the application of biobattery and biogas manufacturing technology were carried out directly in the Sekar Benefit Sekaran TPS3R environment. This training provides a direct understanding of the process of making biobatteries and biogas. The principle of organic waste processing can be used as a source of electrical energy, because the waste can function as the main material in making electrolytes for biobatteries. In addition, through an anaerobic decomposition process that occurs without exposure to free air, organic waste can produce biogas. The main composition of biogas consists of methane gas (CH4) and carbon dioxide (CO2) (Megawati and Aji, 2015). According to Mr. Heru, as the person in charge of TPS3R, only organic waste from fruits and vegetables has been used for maggot food and fertilizer for residents. Furthermore, he said that the daily use of waste can reach 250 kg, while other types of organic waste are underutilized.

These biobatteries and biogas, if operated every day, can increase the utilization of organic waste by 17 kg. The details are that biobatteries require about 5 kg, and biogas requires 12 kg. This increase in capacity is adjusted to the initial prototype of the biobattery and biogas equipment. So if you want to increase the number of tools later, then of course there will also be a lot of organic waste that will be used. For the long term, TPS3R can be used as a means of education and pilot to the community, in managing organic waste. Other TPS3R members expressed their gratitude and gratitude for being involved and contributing to the manufacture of biobatteries and biogas from Billfath University. Furthermore, in the future, he hopes that biobatteries and biogas can become icons at TPS3R Sekar Benefit Sekaran, become a learning medium as well as inspire the surrounding community to utilize organic waste.

The fourth activity is mentoring. This assistance is carried out from the first day of service until later if the biobattery and biogas equipment experiences problems that cannot be solved by the "TPS3R Sekar Benefit" itself. The use of biobattery and biogas conversion tools is a separate maintenance technique. Biobatteries according to the method can be checked periodically once a week to find out whether there is still a current produced. Even if there is damage to the electrodes, the TPS3R team will use used zinc zinc. If the electrolyte is damaged (dry/shrinking), a new electrolyte can be added from organic waste that is still wet. Biogas at this early stage, between the community service of Billfath University and the TPS3R Team has determined the place to place the biogas, and the planting of digesters/reservoirs so that the temperature of biogas remains stable. For safety and periodic maintenance, SOPs and guidebooks will be given.

This service program is expected to be able to provide a real picture, to be able to utilize organic waste, in biobatteries and biogas. The "TPS3R Sekar Benefit" itself or the surrounding community is also expected to increase the quantity and quality of this clean energy according to their needs. Improving quantity and quality will open up opportunities for further research in accordance with the raw materials in TPS3R. This service is also expected to be extended to local residents who have an energy source of organic waste from livestock. So that the community will be able to live a healthy and prosperous life by utilizing and managing waste around it.

CONCLUSIONS AND SUGGESTIONS

The conclusion that can be drawn from this service is that socialization of the use of organic waste for biobatteries and biogas, training in the manufacture of biobatteries and biogas tools, and transfer of the principle of organic waste can be used as a source of electrical energy (biobattery) and heat energy (biogas). The use of organic waste as biobatteries and biogas is able to reduce the amount of waste per day by 17 kg. With the initial manufacture of digesters, it requires 600 kg of organic waste. The utilization of organic waste is able to increase by 240% at the beginning of assembly, and after the appearance of gas, every day the percentage of organic waste use will increase again by 0.05%.

Suggestions for improving this service in the future, where this Beginner Community Service is of course still lacking. Some of these things can still be improved, both in terms of quality and quantity. Activities that can be done for the next stage of service include: it can be by helping to assemble biobatteries according to the load power to be used. In addition, it can also add certain materials or waste, such as crab chitosan to increase the electricity of the biobattery. Biogas production can also be extended to household areas.

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