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Green Mussel Shells as Liquid Organic Fertilizer (CARAJA): Efforts to Utilize Local Potential in Banyu Urip Village Gresik

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Abstract

Banyu Urip Village is one of the villages located in the coastal area of Ujung Pangkah District, Gresik Regency. The local potential of Banyu Urip Village is green mussels, which are a result of the sea catch of fishermen in the local village. This potential is also a problem due to the accumulation of wasted green mussel shell waste that has not been managed optimally. With this problem, the community service team carried out community service activities aimed at providing alternative solutions as well as community empowerment. The method used in the community service activity of making green shell liquid organic fertilizer "CARAJA" is Participatory Action Research (PAR) with subjects of ± 25 people. The community service activities include 4 stages, namely 1) observation with partners, 2) socialization related to the management of green mussel shells, 3) training in making "CARAJA" liquid organic fertilizer and 4) experiments/trials on the use of liquid organic fertilizer on the growth of mustard seedlings. The results of the community service analysis have shown changes in mustard green plant height when using liquid organic fertilizer, and local communities become knowledgeable and skilled in participating in various stages starting from observation, socialization, and training to experiments on the use of liquid organic fertilizer made from green mussel shell powder (CARAJA). In the final stage, with the existence of experiments/trials, additional findings were added to strengthen the fact that the liquid organic fertilizer "CARAJA" can be managed into a product that has a selling value and shows a significant influence in increasing the growth of mustard greens (Brassica Juncea) and optimizing the management of local potential in the village.

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INTRODUCTION

Banyu Urip Village is located in Ujung Pangkah District, Gresik Regency, and is one of the villages located in the coastal area. Most residents work as fishermen with incomes that depend on marine products, especially green mussels (Perna viridis). Most male residents work as fishermen with fish catches sold to middlemen at low selling prices. Meanwhile, the female residents work to help their husbands by separating mussel shells and mussel meat.

Based on the results of observations with partners in early July 2024, Banyu Urip village has the potential for local natural wealth as a producer of green mussels and mangrove tourism. However, the accumulation of green mussel shell waste is worrying the residents of Banyu Urip village. The villagers, especially the fishermen, only manage the mussel meat to be sold to middlemen so that the mussel shells are wasted and waste accumulates. The accumulation of green shell waste has been going on for decades until now, reaching a height of 1-3 meters every week. This situation is very disruptive to the local environmental conditions due to the community's lack of skills and knowledge for effective ways to manage this waste, so waste can accumulate in several locations around the village and finally dumped at the Final Waste Collection Site.

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Waste is the residue produced by individual or group activities without economic value, so special management is needed. Green mussel shell waste accumulating without adequate management can seriously impact the environment and public health. The accumulation of mussel shell waste certainly becomes a nesting place for coli bacteria that can cause diarrhoea or gastroenteritis (Kurniasih *et al*., 2017). If not addressed, the accumulation of shell waste will potentially cause various environmental problems, such as disruption of the balance of the local ecosystem, the emergence of unpleasant odors and can even become a nest for various diseases that can impact the surrounding community's health. Therefore, it is important to immediately find a solution that can overcome this problem effectively and sustainably.

Green mussel shells have a rich content of calcium carbonate (CaCO3), a compound that is beneficial for plants. The calcium carbonate content (CaCO3) in green mussel shells functions as a fertilizer that can neutralize soil acidity in peatlands (Setyowati & Chairudin, 2018). Selain itu, cangkang kerang hijau juga mengandung mineral lain yang bermanfaat bagi tanaman, yaitu P, Mg sebagai hara makro dan Fe, Cu, B, Zn, dan Na sebagai hara mikro serta Ni dan Si.

Several studies have explored using green mussel shells in manufacturing building materials, animal feed mixtures, food processing, and even cosmetic base materials. Recycled green mussel shells are a mixture for making mortar for building materials and enabling environmentally friendly (Leone *et al*., 2023). Shell waste is used as a substitute for fine aggregate in concrete mixtures and can increase the compressive strength of concrete at a shell powder presentation of 5-10% (Karimah *et al*., 2020).

In addition to building materials, the research results on shell waste produced LC 50<1000µg/ml, namely 1127.28ppm, with a non-toxic category to be used as a processed food ingredient (Suhaera *et al*., 2021). Utilization of green mussel shell waste is processed into flour and used as an ingredient in kemplang crackers (Nisa *et al*., 2021). Another innovation that can be done is using green mussel shells as raw materials for making liquid organic fertilizer. This liquid organic fertilizer is environmentally friendly and effective in increasing soil fertility and supporting plant growth naturally, making it a potential solution to the problem of shell waste.

In Banyu Urip village, various research and community services have been conducted to overcome the problem of the potential for abundant green mussel shell waste. The utilization of green mussel shell waste as mussel shell flour, green mussel nuggets, oyster sauce, mussel meatballs and chitosan has increased the understanding of PKK mothers to manage green mussel shell waste into nutritious food products (Handarini, 2022). The 2022 community service activities at the Berkah UMKM, which produces kopang crackers, have helped UMKM actors understand the product production and marketing scheme, processing SPP-PIRT certificate numbers and testing the nutritional content of kopang crackers (Nurdiani *et al*., 2023).

In addition to the food sector, another result of green mussel processing in Banyu Urip village that has been carried out is training in making paving blocks by utilizing green mussel shell waste, but this has not been optimal due to the consideration that the price of raw materials for paving production is relatively high (Kusyairi *et al*., 2022). Reviewing several activities that have been carried out to overcome the problem of abundant green mussel shell waste and the absence of activities related to the management of green mussel shell waste in the agricultural sector in Banyu Urip Village, the community service team is currently offering a solution in the form of making liquid organic fertilizer from green mussel shells "CARAJA".

The training in making liquid organic fertilizer provides education on managing green mussel shell waste. It serves as an experimental study on using liquid organic fertilizer from green mussel shells to grow mustard greens. Efforts are made by converting mussel shell waste, which has been considered useless, into useful products that can improve community welfare and become sustainable waste management models. In the future, this solution also has the potential to be applied in other coastal areas facing similar problems, thus providing a wider positive impact.

MATERIALS AND METHODS

The community service method used is Participatory Action Research (PAR). The type of Participatory Action Research (PAR) has several steps, including 1) knowing the condition of the community, 2) understanding community problems, 3) carrying out problem-solving programs, and 4) building change and sustainability (Afandi, 2022). This community service was conducted from July to August 2024 in Banyu Urip Village, Ujung Pangkah District, Gresik Regency. The steps in the community service carried out by the community service team with the Participatory Action Research approach using 4 stages, namely 1) observation with partners at the location, 2) socialization of the use of green mussel shells was carried out once in the first week, 3) training in making liquid organic fertilizer from green mussel shells was carried out once in the second week, 4) experiments/trials of giving liquid organic fertilizer from green mussel shells "CARAJA" on the growth of mustard greens were carried out once in the third week. The targets of the community service

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activities were fishermen who managed green mussels and residents of Banyu Urip Village who were interested in managing green mussel shell waste.

In the final stage, after the training on making liquid organic fertilizer "CARAJA", the community service team continued the experimental/trial activities to determine the effectiveness of using liquid organic fertilizer made from green mussel shells (CARAJA) on the growth of mustard greens (Brassica Juncea) seedlings. Experimental/trial activities were carried out through treatment on two groups of mustard greens seedlings, namely treatment groups P1 and P2 (each hole was planted with five mustard greens seedlings given treatment in the form of watering liquid fertilizer "CARAJA" with a certain dose, while the control group without treatment P0 (not given treatment of watering liquid fertilizer "CARAJA").

The results of observations in this community service activity were analyzed for their success at the training stage through a final evaluation of the activity. Meanwhile, observations at the experimental/trial activity stage were carried out by interpreting the results of observations of changes in the height of mustard greens daily. Visual and narrative comparisons were carried out to identify differences in the growth of mustard greens between seedlings treated with "CARAJA" liquid organic fertilizer and those not treated with "CARAJA" liquid organic fertilizer. It aims to see the benefits of managing green mussel shell waste as a "CARAJA" liquid organic fertilizer so that it has more economic value and can solve the problem of abundant potential in the local village.

RESULTS AND DISCUSSION

Based on the findings of observations and initial discussions with partners in Banyu Urip village, there is a lot of green mussel shell waste that has not been managed beneficially by the local community. If viewed from the content of green mussel shells, it has a lot of good elements namely the content of mussel shells that have been processed into crackers has a protein content of 5.30%, water content of 13.83%, fat content of 0.69%, ash content of 2.99%, carbohydrates 77.19% (Nurdiani *et al*., 2023).

The content of shellfish also has a high composition of calcium carbonate (CaCO3) and a mineral content of ±98.7% of the total mineral content of Mg, N, P, K, Na and ±1.3% consisting of Fe, CU, Ni, B, Zn and Si (Afrizal, 2016). Nitrogen (N) functions in the formation of green leaf substances for photosynthesis and the formation of proteins, fats, and other organic compounds to fertilize vegetative growth in leaf vegetable plants such as mustard greens. Phosphorus (P) activates plant growth, root growth, flowers and plant maturation. Plants that lack phosphorus will grow stunted, the formation of flowers and seeds will be hampered, and the plants will wilt easily. Potassium (K) helps absorb water and nutrients from the soil, forming starch and protein in plants.

Observation and Discussion with Partners

The community service team conducted observations through discussions with partners in early July 2024. This activity involved discussions with the village head and several residents who manage green mussels. This was done to find out the initial picture of the problems currently being faced by Banyu Urip villagers regarding village potential and the accumulation of green mussel shell waste. The team also reviewed the location of green mussel shell waste accumulation. The observations and discussions resulted in findings that mussel shell waste had not been appropriately managed. The mussel shells were finally dumped at the Final Disposal Site (TPA), and there were several previous activities related to community service and mussel shell research, but the results were not optimal, so new innovations were needed that were expected to be sustainable.

Socialization of The Utilization of Green Mussel Shell Waste

The socialization of the utilization of green mussel shell waste to the residents of Banyu Urip village was carried out in the first week (Fig. 1). The activity began with a presentation related to green mussel shells and their efficient utilization. This activity was attended by around 15 people, including youth organizations, fishing community representatives, and several residents interested in the environment. This was done to educate people about green mussel shells, their content, and the management of shell waste so that they can become useful products. It has an economic selling value for the income of village residents. The community involved in the socialization of green mussel shell waste management has the insight and skills to process and produce green mussel shell waste and market its production (Ramli *et al*., 2022)

Fig. 1. Socialization of the use of green mussel shell waste

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Training on Making Liquid Organic Fertilizer "CARAJA"

This activity was attended by around 15 people, including representatives of the fishing community and several residents interested in the environment (Fig. 2). This was done to provide training in making liquid fertilizer from green mussel shell powder as a form of shell waste management to become a useful product and have an economical selling value for the income of village residents.

a. The composition of the liquid organic fertilizer "CARAJA" is:
   (1) 1 litre of water,
   (2) Green mussel shell powder 200 grams (P1) and 100 grams (P2),
   (3) EM4 agriculture 20 ml
   (4) Molase 20ml.
b. The tools and materials needed are:
   (1) Green mussel shells that have been ground into powder,
   (2) Water
   (3) EM4 agriculture,
   (4) Molase,
   (5) Container for fermentation,
   (6) Digital scales (accuracy level 1 gram),
   (7) Mortar and pestle, crushing machine
   (8) Measuring cup
c. The steps for making liquid organic fertilizer (CARAJA) are as follows:
   (1) Prepare tools and materials
   (2) Crush the shells using a mortar and pestle until they are finely crushed and soft.
   (3) Use a crusher to soften the green mussel shell pieces further, then filter them with a sieve/tea strainer.
   (4) Put water, shell flour, agricultural EM4, and molasses in a fermentation container (the ratio of ingredients is according to the composition)
   (5) Leave it in a closed fermentation container for 7-15 days so that the material ferments well.
   (6) The liquid organic fertiliser is ready after 7-15 days of fermentation.

Fig. 2. Training on making liquid organic fertilizer "CARAJA"

Experiment or Trial of Giving Liquid Organic Fertilizer "CARAJA" to Mustard Green Seedlings

This activity was attended by around 12 people, including youth organizations, fishing community representatives, and several residents interested in the environment. This was done to provide education on how to use liquid organic fertilizer "CARAJA" on plant seeds, as well as provide insight into the benefits and real evidence of changes in the growth of mustard greens seedlings that use liquid organic fertilizer "CARAJA" and do not use liquid organic fertilizer "CARAJA" (Fig. 3).

Fig. 3. Planting mustard greens seedlings in 2 different groups

The community service team uses green mussel shell powder as a mixture of liquid organic fertilizer as a form of innovation and solution because they see the local potential of the village that has not been appropriately managed. Many research findings support that the use of liquid organic fertilizer and green mussel shell waste that has been ground can positively impact the growth of plant seedlings. When crushed, green mussel shells (Perna Varidis) will slowly release Phosphorus, Potassium, and Nitrogen into the soil, adding organic material and improving oil quality (Elfarisna, 2023). In addition to the mixture of shell powder materials, the liquid organic fertilizer "CARAJA" also has an EM4 solution added to its composition as a form of fermentation in liquid fertilizer. This is done because adding an EM4 bioactivator solution to the fermentation process accelerates the fermentation process (Maskur, 2014). EM4 solution contains microorganisms that can accelerate the fermentation process and work effectively on organic materials so that it can be used in fertilizer mixtures.

The main parameter measured in this experimental/trial activity is the height of mustard greens plants with the treatment of liquid organic fertilizer "CARAJA". The stages of the experimental/trial activities carried out in its application are:

(1) Mustard green seedlings were planted in two holes in the ground that had been prepared with

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uniform conditions. Each hole was planted with five mustard green seedlings, with one hole given 2 treatments (P1 and P2) in the form of watering with liquid organic fertilizer "CARAJA" with P1: 1L water + 200 grams of shell powder, P2: 1L water + 100 grams of shell powder, while the other hole was not given the treatment of providing liquid organic fertilizer "CARAJA" and functioned as P0 (control group).

(2) Fertilizer watering in each treatment group, namely the mustard seedling group (P1) and the mustard seedling group (P2) was carried out by mixing 50 ml of liquid organic fertilizer "CARAJA" in 1 litre of water. This solution mixture was then watered as much as 100-200 ml onto the soil with the mustard seedlings that were given treatment twice a week during the observation period. Experimental activities with the specified dosage were also found in other studies, which showed that liquid organic fertilizer in a dose of ±25 ml/litre of water on mustard seedlings significantly affected the growth of mustard plants (Murniati, 2023).

(3) Watering is done in the morning to ensure optimal conditions for nutrient absorption by the plants. Meanwhile, in the control group, mustard greens seedlings without the provision of "CARAJA" liquid organic fertilizer (P0) were only watered with a mixture of water and non-"CARAJA" fertilizer.

(4) Measurement of the height of mustard greens was carried out on the treatment groups (P1 and P2) and the control group (P0) every day for 7 days. Measurements were made using a ruler to ensure accuracy. The growth of mustard greens in the group given caraja fertilizer was compared with that of the control group, which did not receive fertilizer treatment.

Observations were made on the height of mustard greens in two different groups, namely the treatment group of liquid organic fertilizer "CARAJA" as P1: 1L water + 200gr of green mussel shell powder, P2: 1L water + 100gr of green mussel shell powder. While the control group was not given any treatment as P0. On day 1, the height of all mustard green seedlings in the treatment and control groups was in the same condition (Table 1).

Table 1. Average height (cm) of mustard greens

Day	Treatment group (P1)	Treatment group (P2)	Control group (P0)
Day 1	0.0 cm	0.0 cm	0.0 cm
Day 2	0.0 cm	0.0 cm	0.0 cm
Day 3	0.5 cm	0.4 cm	0.2 cm
Day 4	1.1 cm	1 cm	0.7 cm
Day 5	1.9 cm	1.6 cm	1 cm
Day 6	2.7 cm	2.4 cm	2.1 cm
Day 7	3.6 cm	3.3 cm	2.9 cm

Table 1 shows that shoots began to appear on the 3rd day. Plants given "CARAJA" liquid organic fertilizer experienced faster growth than the control group. On the 3rd day, significant differences began to be seen between the group given "CARAJA" liquid organic fertilizer treatment and the control group that was not given "CARAJA" liquid organic fertilizer treatment. This shows that "CARAJA" liquid organic fertilizer began to work effectively within a few days after application. The faster increase in plant height in this treatment group continued until the end of the observation period, indicating that "CARAJA" liquid organic fertilizer not only accelerated initial growth but also maintained consistent plant growth.

Fig. 4. Growth of mustard seedlings on the 5th day

The growth on the 5th day was that the average height of mustard greens in the P1 treatment group reached 1.9 cm, P2 reached 1.6 cm, and in the P0 control group, it was only 1 cm (Fig, 4). The growth on the 6th day was that the average height of mustard greens in the P1 treatment group reached 2.7 cm, P2 reached 2.4 cm, and in the P0 control group, it was only 2.1 cm (Fig. 5).

Fig. 5. Growth of mustard seedlings on the 6th day

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Fig. 6. Growth of mustard seedlings on the 7th day

On the 7th day, the average height of mustard greens in the P1 treatment group reached 3.6 cm, P2 reached 3.3 cm, while in the P0 control group, it was only 2.9 cm (Fig. 6).

In line with these findings, other studies also stated that there was a difference in the increase in plant height with three treatments of liquid organic fertilizer P1 as much as 15 ml/litre of water with a plant height of 2.2 cm from the group without treatment, P2 as much as 20 ml/litre of water with a plant height of 5.13 cm from the control group, P3 as much as 25 ml/litre of water as much as 9.03 cm from the control group, even a significant increase occurred until the 30th day of planting (Aryani & Musbik, 2018).

The results of the observation analysis of the treatment of giving liquid organic fertilizer, "CARAJA" which comes from green mussel shell powder, has proven to have a positive effect on the growth of mustard greens up to the 7th day of planting. These results are in line with the fact that plants more easily absorb liquid organic fertilisers because the ingredients have been broken down with a mixture of water and other ingredients (Aryani & Musbik, 2018).

Liquid organic fertilizer also increases productivity in plant parts by increasing the number of leaves, stem height, and root strength. Liquid organic fertilizer added with a green mussel shell powder mixture also increases plant productivity (Elfarisna *et al*., 2021). This is likely due to the content of calcium carbonate ($CaCO_3$) and other minerals found in green mussel shells, which can increase soil fertility and improve plant growth conditions. In addition, the organic content in caraja fertilizer can increase the availability of nutrients for plants so that plants can grow faster and stronger.

In line with these results, other studies have found that providing fertilizer with a mixture of shell flour can be an alternative to replace dolomite and is more efficient with a certain dose. It can produce growth of the same plant parts (Setyowati & Chairudin, 2018). Fertilization of shell flour fertilizer increased in plant parts, namely the height of spinach plants at the age of 7, 4 and 21 days in stem diameter, number of spinach leaves and fresh weight of spinach. This indicates an increase in plant growth through increased soil structure and availability of nutrients from the content of shells.

Meanwhile, when viewed from the analysis of the content elements in green mussel shells and soil pH, at the pH level of waste, green mussel shells can reduce the acidity level in liquid waste processing (Ruhyat & Pribadi, 2022). These findings illustrate that green mussel shell waste can also be a filter medium for liquid waste from tofu processing.

Research conducted by Elfarisna *et al*. (2021)regarding using green mussel shell waste in pakcoy plants shows that green mussel shell waste contains elements including P 0.09%, K 0.02%, Ca 52.50%, Mg 0.07% and S 0.03%. Mussel shell waste also produces a high pH of 9.4. The analysis results of the treatment of giving a mixture of shells can increase the pH from 4.1 to ±7.00. This occurs because green shells contain Ca and Mg, so the soil has an increase in pH.

In addition to containing Ca and Mg, the given shell flour also contains other elements such as zinc and iron found in the soil after the soil pH increases to become non-acidic. Low acidity levels can affect plant growth. In experimental activities through the administration of liquid fertilizer made from shell powder on mustard greens, there has been a significant difference in height between the treatment and control groups, indicating that the liquid organic fertilizer "CARAJA" has good potential as an alternative organic fertilizer to support the growth of mustard greens.

Fig. 7. Liquid organic fertilizer product "CARAJA"

The results of community service related to the training on making liquid organic fertilizer "CARAJA" and the results of experiments conducted on mustard greens with the treatment of giving liquid organic

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fertilizer "CARAJA" have proven successful in improving the management and utilization of green mussel shell waste as a liquid organic fertilizer material for mustard greens in Banyu Urip Village, Ujung Pangkah, Gresik. In addition, the experimental activities of the liquid organic fertilizer "CARAJA" that have been made effectively increase the growth of mustard greens in these experimental conditions. The use of liquid organic fertilizer "CARAJA" can be an environmentally friendly solution to utilize green mussel shell waste that has been underutilized. However, further community service or research is needed over a longer period of time and on various types of plants to evaluate the full potential of this liquid organic fertilizer "CARAJA" (Fig. 7).

CONCLUSION

Community service activities with the Participatory Action Research (PAR) approach showed the local community's enthusiasm in participating in various stages, from observation, socialization, and training to experiments/trials on using liquid organic fertilizer made from green mussel shell powder (CARAJA). In the final stage, with the existence of experiments or trials, it added to the strengthening findings that liquid organic fertilizer "CARAJA" can be managed into a product that has a selling value and shows a significant influence in increasing the growth of mustard greens (Brassica Juncea). At the end of the 7-day observation, plants treated (P1 and P2) with liquid organic fertilizer "CARAJA" had a greater average height, namely ±3.9cm and better physical conditions, such as greener leaves and stronger stems. The plant seedlings that were not treated (P0) had a smaller average height, namely ±2.6cm. The effectiveness of liquid organic fertilizer "CARAJA" can be associated with the nutrient content that increases soil fertility and the availability of other nutrients for plants. Thus, the results of the analysis obtained from this community service show that the liquid organic fertilizer "CARAJA" not only has the potential to be an alternative environmentally friendly organic fertilizer but also becomes innovation and utilization of green mussel shell waste as a local village potential in a sustainable manner, especially in the coastal areas of Banyu Urip Village, Gresik and the other regions.

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