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Influence of addition surimi wastewater to macronutrient content (nitrogen, phosphor, and potassium) of gracilaria sp. Liquid organic fertilizer

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Abstract
Purpose: The purpose of this study was to determine the increase in the nutrient content of nitrogen, phosphorus, and potassium in Gracilaria sp. liquid organic fertilizer containing surimi wastewater.
Research Methodology: The study used an experimental method with a completely randomized design consisting of four treatments and five replications. The treatment used was the addition of 0 %, 80 %, 90 %, and 100% surimi wastewater. The macronutrient content (nitrogen, phosphorus, and K) of the fertilizer was measured after 14 days of fermentation.
Results: The results of this study indicate that the addition of surimi wastewater can increase the content of nitrogen, phosphorus, and potassium in Gracilaria sp. liquid organic fertilizer, and the results were significantly different ($P < 0.05$).
Limitations: This study was limited by its small sample size and short study period.
Contribution: This study found that the addition of surimi wastewater to Gracilaria sp. Liquid organic fertilizers can increase the macro-nutrient content of the fertilizer. This suggests that surimi wastewater can be used as a sustainable and cost-effective source of nutrients in liquid organic fertilizers.
Keywords: *Gracilaria sp., surimi wastewater, macronutrient*
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1. Introduction

Indonesia, with its large agricultural population and diverse agricultural sectors, faces a major challenge in providing adequate organic fertilizer to support sustainable agriculture. The "Go Organic 2010" initiative launched by the government is a strategic step to increase the use of organic fertilizers in agriculture (Mayrowani, 2012). This initiative created awareness of the importance of organic farming as a measure to protect the environment and human health. Organic farming focuses on the use of organic materials such as organic fertilizers as a more natural and sustainable alternative to inorganic fertilizers that tend to pollute the environment. The need for organic fertilizers in Indonesia is an important issue in the context of sustainable agriculture and the government's efforts to reduce dependence on inorganic fertilizers that have the potential to damage the environment. The need for organic fertilizer in Indonesia in 2013-2017 reached an average of 926,932.4 tonnes per year, but organic fertilizer production in Indonesia only met 57.7% of the national demand (KP, 2018). Nurhaedah, Irmayani, Ruslang, and Jumrah (2023) stated that one of the main challenges in meeting the needs of organic fertilizer in Indonesia is the limited supply of raw materials. The main raw materials for organic fertilizer production are usually animal manure and plant waste. However, the supply of these raw materials has not been adequate to fulfil the increasing demand. Ramlan, Irmayani, and Nurhaeda (2023) highlighted this constraint and underlined the importance of having a consistent and sufficient supply of raw materials to support wider organic fertilizer production. With limited feedstock supply, organic fertilizer production is hampered, and this impacts efforts to increase the use of organic fertilizer in agriculture in Indonesia.

One of the materials from the fisheries sector that has potential as a solution for national organic fertilizer production is Gracilaria sp. Gracilaria sp. is a seaweed that has potential as an organic fertilizer based on its nutrient content and production amount. Gracilaria sp. contains nutrients (N, P, K, Ca, Mg, Mn, Zn, Fe, Co and B) and hormones (auxins, gibberellins, and cytokinins) needed for plant growth (Francavilla et al., 2015). Gracilaria sp. production in Indonesia in 2012-2016 reached an average of 928,985.4 tonnes per year with an average growth rate of 16.684% (Ferdouse, Holdt et al. 2018). One of the fertilizers produced from Gracilaria sp. seaweed is Gracilaria sp. liquid organic fertilizer. Gracilaria sp. liquid organic fertilizer is a solution containing macro nutrients (N, P and K), micro nutrients (Ca, Mg, Mn, Zn, Fe, Co and B) and hormones (auxins, gibberellins, and cytokinins) derived from Gracilaria sp. seaweed compost (Sedayu, Erawan, & Assadad, 2014). The weakness of Gracilaria sp. liquid organic fertilizer is the macro nutrient content (N, P and K) of 0.41%, 4.5 x 10-4% and 3.4 x 10-5% respectively, while the standard macro nutrient content of fertilizer according to SNI-19-7030-2004 is 0.48%, 0.10% and 0.20% (Sedayu et al., 2014). Macro-nutrients are one of the quality parameters of organic fertilizer, besides that the higher the nutrient content of fertilizer will increase the efficiency value in fertilizer application (Gellings & Parmenter, 2016).

surimi wastewater. Surimi wastewater is a by-product of surimi production in the process of washing fresh fish, fish fillets and washing minced fish meat (Borgstrom, 1965). Ratrinia and Uju (2017) reported that surimi wastewater can increase the macro nutrient content (N, P and K) of Sargassum sp. liquid organic fertilizer by 0.003%, 0.005% and 0.175% to 0.074%, 0.043% and 0.274%, respectively. The surimi sector faces a significant challenge due to the large quantity of liquid waste generated, which imposes a financial strain on its management. According to Stine et al. (2012), the surimi sector faces difficulties due to the large amount of liquid waste it produces. These concerns mostly revolve around the expenses associated with treating the waste before it is released into the environment. A study conducted by Afonso and Borquez (2002) found that the manufacturing of one kilogramme of surimi results in the generation of approximately 27–29 litres of surimi liquid waste. Nevertheless, despite the substantial surimi production in Indonesia, amounting to 340,625 metric tonnes annually, the resulting effluent volume is considerable. Afonso and Borguez highlight that in the process of producing surimi, the quantity of wastewater produced greatly surpasses the quantity of the final surimi product.

The concern lies not just in the magnitude of the problem but also in the potential environmental consequences it may entail. Surimi wastewater frequently contains significant quantities of organic substances. If this waste is not adequately treated before disposal, it can have detrimental effects on the ecosystem. A study conducted by Aran, Bourneow, and Benjakul (2012) found that Surimi effluent with a high concentration of organic matter can contaminate the environment, leading to the emission of unpleasant odours, the excessive growth of algae in water bodies, and the deposition of sediment in water bodies. The study demonstrates that inadequate management of Surimi wastewater might have detrimental effects on environmental quality and water sustainability. Nevertheless, endeavours to tackle the issue of surimi wastewater have also generated substantial prospects. By employing this waste as a primary ingredient in the manufacturing process of Gracilaria sp. liquid organic fertilizer, we may transform trash from being a burden into a profitable asset. This method offers a novel approach to tackling environmental issues while also promoting the creation of superior and eco-friendly organic fertilizer. Therefore, incorporating surimi liquid waste into the manufacturing process of liquid organic fertilizer derived from Gracilaria sp. can effectively tackle the problem of national organic fertilizer demand, promote the "Go Organic 2010" campaign, and open up possibilities for the surimi industry to enhance its role in sustainable agriculture and environmental preservation. Furthermore, this study signifies a significant advancement in investigating innovative methods for generating valuable commodities from industrial refuse, thus contributing positively towards the establishment of a more environmentally friendly circular economy.

2. Methods

2.1 Materials and Tools Preparation

The materials used in this study were *Gracilaria* sp., Surimi waste water, bioactivators (*Rhodopseudomonas* sp., *Streptococcus lactis*, *Lactobacillus* sp., *Streptomycetes* sp. And *Saccharomyces* sp.), H_2SO_4 (Merck), NaOH (Merck), H_3BO_3 (Merck), mixed indicators (MR and BCG), HClO (Merck), Ammonium heptamolipdate venadate (Merck), HNO_3 (Merck), Ammonium molybdate tetrahydrate (Merck), Selenium reagent mixture (Merck), CsCL (Merck)), distilled water, Strain *Chlorella* sp., sea water and walne. The tools needed in this research are reactor, Atomic Absorption Spectrophotometer (AAS) (Shimadzu type AA 6300), Kjeldahl system and 1700 PC dual beam UV-Vis spectrophotometer (Shimadzu) and binocular microscope (Nikon / eclipse E- 100 LEDs)

2.2 Preparation of Fertilizer

Gracilaria sp. liquid organic fertilizer using methods Sedayu et al. (2014), by modifying the addition of trash fish into surimi liquid waste. 300 grams of seaweed, 60 ml of surimi liquid waste and 8% bioactivator solution of 20 mL were put into the reactor. Fermentation under anaerobic conditions for 7 days.

Table 1. Fertilizer Formulation

Treatment	Bioactivator	*Gracilaria* sp.	SSW	Water
P0	1,6 mL	300 gram	-	77,4 mL
P1	1,6 mL	300 gram	48 mL	29,4 mL
P2	1,6 mL	300 gram	54 mL	23,4 mL
P3	1,6 mL	300 gram	60 mL	-

Note: SSW = surimi waste water

2.3 Study Stage

The difference in the concentration of surimi liquid waste refers to the research of (Ratrinia & Uju, 2017), P0 (surimi waste water 0%), P1 (surimi waste water 80%), P2 (surimi waste water 90%), P3 (surimi waste water 100%)

2.4 Analysis Nitrogen Content

Analysis Nitrogen content refers to the Kjeldahl method (Horwitz, 2010). This testing method is with three stages, destruction, distillation, and titration. Destruction using 500 mg samples, 96 ml H_2SO_4 as much as 15 ml, Selenium reagent mixture as much as 0.5 grams and heated at 370°C to clear solution, then distillation using 45% NaOH. The distillate is accommodated in 1 ml of H_3BO_3 solution as much as 10 ml and given three drops of methyl red (MR) and bromo cressol green (BCG) then titrate with 0.05 N H_2SO_4 solution until the color turns pink.

2.5 Analysis Phosphor Content

Analysis phosphorus content using the reference Spectrophotometry method (Pramono & Indriyani, 2019). Testing of phosphorus levels was carried out using a sample of 500 mg, heated at 270°C for 90 minutes with 5 ml of 5% HNO_3 added and 70 ml of HClO of 3 ml. Clear extract was taken as much as 20 ml and mixed with 5 ml Molibdovanadat solution then allowed to stand for 30 minutes. Observation with a UV-Vis spectrophotometer at a wavelength of 420 nm and compared with a standard solution (0: 0.5: 1: 2: 3: 4).

2.6 Analysis Potassium Content

Analysis potassium content were tested based on the Flamephotometry method (Pramono & Pratama, 2020). Potassium content were tested using a 500 mg sample, heated at 270 ° C for 90 minutes with 5 ml of 5% HNO_3 added and 70 ml HClO of 3 ml. A clear extract was taken 20 ml and added as much as 2.5 ml potassium suppressor, then observed at the Atomic Absorption Spectrophotometer (AAS) at a wavelength of 420 nm and compared with a standard solution (0: 0.5: 1: 2: 3: 4: ppm).

2.7 Data analysis

Data obtained were analyzed using ANOVA (Analysis of Variance) test, then continued using Duncan's multiple range test with 5% degree of confidence whether all treatments showed significant difference (Kusriningrum, 2008).

3. Results and Discussion

The results of the study are data of macro nutrient content (nitrogen, phosphorus and potassium) from *Gracilaria* sp. liquid organic fertilizer The results are used to determine the effect of giving surimi waste water to macro nutrient content (nitrogen, phosphorus and potassium) *Gracilaria* sp.liquid organic fertilizer.

Table 2. Nitrogen Content

Treatment	Nitrogen(%) ±SD
P0	0,12^{c} ±0,04
P1	0,25^{b} ±0,08
P2	0,29^{b} ±0,08
P3	0,54^{a} ±0,09

Note: P0 (0% surimi waste water), P1 (80% surimi waste water), P2 (90% surimi waste water) and P3 (100% surimi waste water). Different superscripts show significant differences ($p < 0.05$).

ANOVA results show that the addition of surimi waste water in *Gracilaria* sp. liquid organic fertilizer. significantly influence ($p < 0.05$) on nitrogen content, Duncan's multiple range test was performed. The results showed that the highest nitrogen levels were found at P3 each 0.54%, while the lowest was obtained from P0 with 0.12%..

Table 3. Phosphor Content

Treatment	Phosphor(%) ±SD
P0	0,07^{c} ±0,03
P1	0,23^{b} ±0,11
P2	0,17^{bc} ±0,09
P3	0,35^{a} ±0,09

Note: P0 (0% surimi waste water), P1 (80% surimi waste water), P2 (90% surimi waste water) and P3 (100% surimi waste water). Different superscripts show significant differences ($p < 0.05$).

ANOVA results show that the addition of surimi waste water in *Gracilaria* sp. liquid organic fertilizer. significantly influence ($p < 0.05$) on phosphor content, Duncan's multiple range test was performed. The results of this test obtained the lowest phosphor content found at P0 with 0.07%. P2 with a phosphor content of 0.17% did not differ significantly from P0 and P1 with 0.07% and 0.23%, P3 was found to have the highest phosphorus content with 0.35%.

Table 4. Potassium Content

Treatment	Potassium(%) ±SD
P0	1,86^{d} ±0,08
P1	2,34^{b} ±0,08
P2	2,19^{c} ±0,11
P3	2,56^{a} ±0,09

Note: P0 (0% surimi waste water), P1 (80% surimi waste water), P2 (90% surimi waste water) and P3 (100% surimi waste water). Different superscripts show significant differences ($p < 0.05$).

ANOVA results show that the addition of surimi waste water in *Gracilaria* sp. liquid organic fertilizer. significantly influence ($p < 0.05$) on potassium content, Duncan's multiple range test was performed. The results showed that the highest potassium content were found at P3 each 2.56%, while the lowest was obtained from P0 with 1.86

3.1 Discussion
Based on the results of this study, the addition of surimi liquid waste in the process of making Gracilaria sp. liquid organic fertilizer has a significant effect ($p<0.05$) on increasing the content of nitrogen, phosphorus, and potassium nutrients. Gracilaria sp. liquid organic fertilizer with the addition of 100% surimi liquid waste is the best treatment because it produces the highest nitrogen, phosphorus, and potassium content, namely nitrogen 0.54%, phosphorus 0.35%, and potassium 2.56%. The addition of 100% surimi liquid waste in the process of making Gracilaria sp. liquid organic fertilizer meets the quality standards of compost (SNI-19-7030-2004), namely nitrogen, phosphorus, and potassium levels of 0.48%, 0.10%, and 0.20%, respectively. The results showed that the addition of surimi liquid waste had a significant effect on increasing the nutrient content of nitrogen, phosphorus, and potassium in the liquid organic fertilizer. The addition of 100% surimi wastewater proved to be the best treatment, producing the highest nitrogen, phosphorus, and potassium contents, in accordance with compost quality standards.

The addition of surimi wastewater can increase the nitrogen, phosphorus and potassium content of Gracilaria sp. liquid organic fertilizer because surimi wastewater contains 0.33% nitrogen, 0.08% phosphorus and 0.17% potassium. Compared to (Ratrinia & Uju, 2017) surimi liquid waste derived from catfish has a nitrogen content of 2.5 x 10-5%, phosphorus 2.45 x 10-5% and potassium 18.9 x 10-5%, lower than the surimi liquid waste derived from the surimi industry UD. ANELA which is derived from swallowfish (Nemipterus nematophorus). The addition of surimi liquid waste increases the nitrogen, phosphorus and potassium content of Gracilaria sp. liquid organic fertilizer due to the nitrogen, phosphorus and potassium content of surimi liquid waste, in addition because surimi liquid waste can increase the activity of decomposing microorganisms. This is proven by Ratniani et al. (2016) that the results of microorganism testing on 600 mL of surimi liquid waste can produce a population of degrading microorganisms of 10,400 CFU/mL. The main component of surimi liquid waste is protein which can be utilised by microorganisms as a source of carbon and nitrogen (Ningsih et al., 2016). It is important to note that the addition of surimi effluent not only increases the nutrient content, but can also increase the activity of degrading microorganisms. Previous research results show that surimi effluent can support the growth of decomposer microorganisms with significant populations. This illustrates the important role of surimi effluent in activating the nutrient decomposition process in Gracilaria sp. liquid organic fertilizer.

The macro-nutrients (nitrogen, phosphorus and potassium) of Gracilaria sp. liquid organic fertilizer are the result of the nutrient decomposition process using microorganisms from bioactivators (effective microorganisms) as decomposers (Sedayu et al., 2014). Bioactivators (effective microorganisms) contain microorganisms that are influential in degrading nutrients into nutrients, namely Rhodopseudomonas sp, Lactobacillus sp, Actinomycetes sp, and Saccharomyces sp (Hu & Qi, 2013). Research by Van Fan et al. (2018) proved that microorganisms in bioactivators (effective microorganisms 4) can be used as decomposers of nutrients into nutrients because these microorganisms can produce amylase, lipase, cellulase, and proteinase enzymes during the composting process. Research by (Sundari, Ma'ruf, & Dewi, 2014) proved the effectiveness of bioactivators (effective microorganisms 4) in liquid organic fertilizer Gracilaria sp. with the addition of bioactivators (effective microorganisms 4) produced higher phosphorus and potassium nitrogen content compared to those that did not add bioactivators (effective microorganisms 4).

The degradation process using bioactivators (effective microorganisms 4) occurs under mesophilic and thermophilic conditions as composting progresses (Sánchez, Ospina, & Montoya, 2017). Rhodopseudomonas sp., Saccharomyces sp. and Lactobacillus sp. are active under mesophilic conditions (30 - 45°C), these microorganisms degrade carbohydrates, proteins and lipids and produce exothermic reactions that increase the composting temperature which can reach 45 - 60°C (Bernal, Alburquerque, & Moral, 2009; Insam & De Bertoldi, 2007). Under these conditions, mesophilic microorganisms become less competitive and their degradation role is replaced by thermophilic microorganisms. Thermophilic conditions make Actinomycetes sp. microorganisms active in degrading complex molecules such as cellulose, lignin, hemicellulose and proteins (Bernal et al., 2009; Yahya &

Yani, 2023), under thermophilic conditions, Actinomycetes sp. microorganisms become active in degrading complex molecules such as cellulose, lignin, hemicellulose, and proteins. This creates a level of diversity of degrading microorganisms that can act on various organic components in liquid organic fertilizer. This process illustrates how different types of microorganisms play a role in decomposing complex organic components, ultimately improving the quality of liquid organic fertilizer.
The results of this study provide valuable insights into the potential use of surimi liquid waste and the use of bioactivators in the production of liquid organic fertilizer Gracilaria sp. This method can contribute to the development of higher quality and sustainable organic fertilizer products, and can assist in efficiently managing surimi industry waste. Further research could explore ways to optimise composting conditions and bioactivator composition to improve nutrient decomposition efficiency and liquid organic fertilizer quality.

4. Conclusions

Surimi wastewater can increase levels of nitrogen, phosphorus, and potassium from *Gracilaria* sp. liquid organic fertilizer, Even the fertilizer can increase the growth of plankton *Chlorella* sp.

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