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The Circular Economy Strategy of Reusing Mangrove Waste in the Mangrove Nurseries

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Abstract:- The implementation of the circular economy in Indonesia has received special attention from the government. This is evidenced by the existence of a circular economy implementation master plan made by the government until 2025. The circular economy is a concept of processing waste into a product, and then the product is reused for raw materials or additive materials. In the mangrove nursery business, leaves, litter, and mangrove twigs in the form of waste are processed to become vermicompost with the help of L. Rubellus worms. Physico-chemical analysis showed that during the vermicomposting process, the N, P, and K content increased while the pH, organic total and C/N ratio decreased. Study results show that vermicompost is useful for increasing soil fertility, increasing the number of microbes in the soil, increasing the nutrients in the soil and increasing plant growth. Economic analysis shows that the vermicompost business using 840 kg of earthworms and 10,000 Kg of compost costs 4000 USD., generates profit, and the BEP point is reached in the seventh month.

Keywords:- *Mangrove Nursery, Leaf Litter, Circular Economy, Vermicompost*

I. INTRODUCTION

Nagelkerken et al.1] stated that mangroves function as a habitat for land and sea biota, where birds inhabit the habitat above the mangroves, insects, mammal and reptiles; sponges, algae and bivalves inhabit the underwater habitat; and fish, crabs and shrimp inhabit the habitat between the mangrove roots. As an ecosystem, mangroves are a habitat for various biota. Various biota types live in mangrove forests because this ecosystem provides various types of food sources ranging from litter and mangrove fruit. In addition, mangroves also become nursery grounds for this biota because mangrove forests provide shelter from predators. Therefore, damage to mangrove forests can threaten the life of biota and other organisms and threaten human life.

Mangrove forest rehabilitation can be done in natural or artificial ways. Mangrove forest rehabilitation can be done by rehabilitating mangrove areas or mangrove reforestation. Rehabilitation naturally occurs if the fruit falls and grows on the substrate. In contrast, artificial rehabilitation is carried out by humans by carrying out nurseries and replanting the seeds that have grown in their natural habitat. For the maximum growth of mangrove seedlings, organic fertilizers are needed, which are rich in nutrients. Organic fertilizers can be made from leaf litter or solid waste from mangroves. Using the circular economy concept, the utilization of mangrove waste for mangrove nurseries is an effort to protect the environment.

The circular economy makes a product whose raw materials come from recycled waste. Through this recycling process: (i) waste, emissions, and wasted energy can be minimized, (ii) save fuel, save raw material costs[2], (iii) reduce the use of unsustainable materials, saving costs and creating zero waste [3].

In Indonesia itself, the importance of the circular economy concept has been realized by the government where the Ministry of Industry of the Republic of Indonesia has established five main principles of the circular economy concept through: reducing the use of raw materials from nature (reduce), optimizing the use of materials that can be reused) and the use of materials resulting from the recycling process as well as from the recovery process or by carrying out repairs (kemenperin.go.id). Developing a business model is one of the government's programs in 2018-2019 to support implementing a circular economy in Indonesia. Which is based on a circular economy as evidenced by the existence of a circular economy implementation master plan until 2025, which is shown in Figure 1 below

Fig 1 Master plan for circular economy implementation in Indonesia
(Source: Ministry of Environment and Forestry, 2017)

Mangrove forest areas commonly found on the coast, besides functioning to protect the coastal environment, also produce solid waste in the form of leaf litter, twigs, and wood. If this waste is allowed to accumulate, it will pollute the environment in the mangrove forest area. This waste contains minerals and organic matter, which can be processed into vermicompost and used as a source of nutrition in mangrove nurseries. Vermicompost preparation from mangrove waste and using vermicompost for mangrove nurseries is a circular economic concept. For this seaweed nursery business to be improved and developed by producing new products, a robust business model that involves all elements that describe how an organization can create, capture, and deliver value is needed [4].

In general, the business model reveals how the company conducts its business through its activities, how it operates, and how to create value for its customers and gain profits by taking into account the preservation of resources so that the mangrove nursery business in carrying out its activities can obtain maximum profits, but natural resources remain sustainable [5]. For this reason, a circular economy approach estimates the biological, economic, and social aspects of conducting a seaweed cultivation business.

The circular economy approach refers to an economic system designed to be restorative and generative[6],maintain the value of products, raw materials, and energy sources and minimize waste production (EU Commission, 2015). Circular economy theory shows that increasing resource efficiency and reducing waste over the life cycle of the goods produced are unexplored economic opportunities that have the potential for economic growth [7]. Circular Economy is often discussed through the 3R principles: reduce, reuse and recycle [8. This principle of reduce or reduce implies using minimal energy, raw material, and waste inputs by, for example, implementing better technology, simplifying, and using simple equipment [9]. The principle of reuse is a principle that refers to the use of fewer resources, less energy, and less labor than needed to produce new products from new materials or even to recycle and dispose of products [10].The principle of recycling or recycling refers to recovery operations in which waste materials are reprocessed into products, materials, or materials, either for their original use or other uses.

Sergio and Alejandra [11]. They have implemented a circular economy system at a restaurant in Mexico by making a biogas factory from the restaurant's solid waste and utilizing biogas as fuel for cooking. The average restaurant produces 40.5 kg of solid waste per day or in the form of sludge 69.2 L/day, containing 23% total solids and 94.2% total volatile solids (TPV). Based on the solid waste volume, Sergio and Alejandra [11]. Designed a biogas plant installation with an estimated factory investment cost of USD and produces 6.1 m^3/day of biogas. The biogas produced fulfills about 6% of the total fuel demand. The economic evaluation results show that a biogas plant's profitability is highly dependent on the price of LPG gas and can save as much as 692 Kg/year of LPG usage.

The problem faced by the Caffe Cagliari coffee roasting company in the city of Modena, northern Italy, is the need for LPG fuel which is quite large. To solve this problem, Giulio et al. [12] use the circular economy concept by turning coffee grounds into briquettes. Then the briquettes are used to roast the coffee beans. Research shows that Caffe Cagliari roasts 5 tons of coffee daily, with 25 roasting times. The roasting temperature is 95-220^{0}C, requiring 400 m3 of LPG/day at an LPG price of 0.62€/m3. The cost required for LPG is 248€/day. The trial results by using briquettes, Caffe Cagliari can save fuel costs 10398 €/day and reduce CO_2 emissions from 71690kg/year to 5135kg/year.

Processing food waste into fertilizer and using fertilizer for plants is a circular economic concept applied by Muhammad and Rashid[13] in the holy city of Mecca. Indicators of the success of the circular economy concept were analyzed from the potential for compost production from food waste and the economic benefits of compost nutrients (C, N, P, and K) to replace chemical fertilizers. Savings in transportation costs because there is no need to take food waste to the TPA. Circular economy Figure 2 below shows the circular economic cycle of composting from food waste.

Fig 2. The circular economy of food waste processing

Muhammad and Rashid [13] report that the production of food waste in the city of Makkah is estimated to increase every year. In 2015 the amount of food waste was 0.92 Mt; 2015 projected to be 1.35 Mt in 2030. A large amount of food waste is due to the growth of the domestic population and the number of Hajj and Umrah pilgrims. If this food waste is processed, it will produce 0.23-0.40 Mt of compost in 2015–2030 and reduce 0.043-0.076 Mt of CH_4 emissions. It is estimated that 0.23 Mton of compost produced can replace 2.8, 0.7 and 0.9 kt of synthetic fertilizers from Urea, TSP and NPK, saving 67 MSAR (billion ryals). The projected production of 0.40Mt of compost in 2030 can replace 4.8, 1.2 and 1.7kt of Urea, TSP and NPK fertilizers. It will also enrich the soil with 28.9 ktons C, replace 119.4 kt of carbon source fertilizers such as humic acid, and save 117 MSAR in fertilizer procurement costs.

Korhonen et al.[14] explain that implementing a successful circular economy will contribute to the economy, environment, and society. Incineration of waste should be the second or last option, while disposal to the TPA should be the last option. The business model developed in the mangrove nursery is a circular economy model, in which solid waste from making agar paper, in the form of twigs, and leaf litter, is processed into vermicompost. This way, value, quality, value chain and product cycle can be maintained. Product reuse, remanufacture, and refurbishment demands fewer resources and energy and is more economical. Applying business models in companies has several benefits, including making it easier for companies to make decisions and test the market as a reference for developing business. In addition, the business model is also designed to determine internal competence as material for consideration in planning decision-making and determining strategies to capture existing opportunities.

II. METHOD

A. Material and Apparatus

Native earthworm species, L. Rubellus, was obtained from the Vermiculture Unit of the Biology Department at Budi Utomo University. The material consists of waste seaweed, cow dung, and earthworms. Seaweed waste was obtained from an agar-agar paper factory in Sidoardjo, East Java, Indonesia. The samples were placed in plastic bags and brought to the Mekar Sari Co, a seaweed nursery company. The cow dung (CD) was collected from nearby cattle sheds in fresh form and allowed to stabilize for one week and used in this study. The stabilization of CD was done to make it acceptable to earthworms.

B. Preparation of Worm Media

Seaweed solid waste dried in the sun until dry Cow manure was soaked in water for 24 hours and dried in an oven at 100^0C for 3 hours. Worm media formula with a composition of seaweed waste and cow dung ratio 1:1. The mixture is stirred evenly, then put into the fermenter for ten days to form compost.

C. Vermicompost Preparation

The worm house was made of wooden racks with dimensions of 120 cm x 80 cm x 12 cm, 6 of which were filled with 300 kg of compost and 20 kg of worms. Pay attention to the position of the worm, and if the worm moves up, it means the temperature is too high; spray water on the surface of the media so that the media becomes moist. Every 14 days for 56 days, the weight of the earthworms and the weight of the vermicompost were measured to know the change in the initial weight of the earthworms and the weight of the vermicompost produced. Store the vermicompost in a closed container and analyze the chemical content of the vermicompost.

III. RESULT AND DISCUSSION

A. Psycho Chemical Parameter Compost and Vermicompost

The psycho-chemical parameters of compost and vermicompost are shown in Table 1

Table 1. Psycho-chemical compost and vermicompost

No	Para meter	Initial	Com post	Vermi compost
1	pH	8,51	7.90	7.15
2	TOC	31.32	29.30	23.60
3	N	0.86	1.10	1.48
4	P	0,39	0.45	0.75
5	K	1,65	1.75	2.30
6	Mg	1,38	1.45	1.96
7	Ca	0,39	0.43	0.60
8	Na	0,64	0.64	0.52
9	Zn	0,53	0.54	0.54
10	C/N	36,40	25.40	16.10

From Table 1, it can be see that the pH, TOC and C/N ratios decreased after composting or vermicomposting. At the same time, other parameters, such as N, P, K, Mg, and Ca, increased after composting and vermicomposting. The increase in the ionic content of vermicompost is due to the decomposition of organic carbon into carbon dioxide through respiration and the addition of nitrogen by the activity of earthworms. Jayanta et al. [15] reported an increase in the content of TKN, TP and TK in vermicompost from f Parthenium hysterophorus, Azadirachta indica, Argemone mexicana, and Vitex negundo v s transformed with CD using the earthworms Eisenia fetida and Perionyx excavatus and similar reports have also been made during vermicomposting of different organic substrates by Amir, and Fouzia [16], Ramachandran et al. [17], Fu et al. [18], Suthar et al. [19]. and Yuvaraj et al. [20]. In addition, the increase in TP levels during vermicomposting was caused by phosphatase activity originating from earthworms and increased microbial activity in the cast [21].

B. Production of Vermicomposting

The results of observing vermicompost production for 90 days and observed every 14 days, using 9800 kg of compost and 840 kg of earthworms.

With an investment cost of 4000 USD and operational costs of 300 USD/month, the price of vermicompost and earthworms is 0.7 USD/kg each, and the price of earthworms is 2 USD/kg, income can be predicted and the Break-Even Point (BEP) was reached in the seventh month, as shown in Figure 3 below.

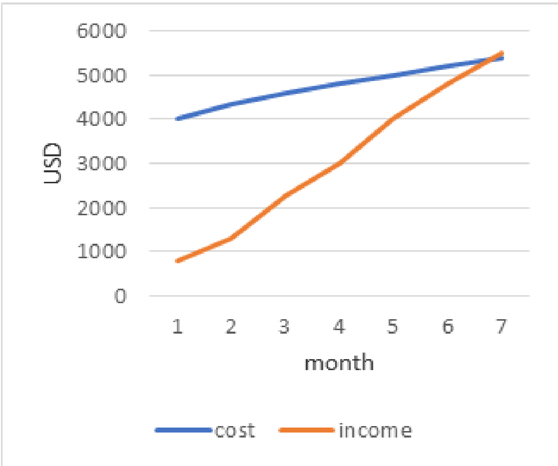

Fig 3 break event point

The circular economy process in mangrove nurseries starts with mangrove nurseries' collection of leaves, twigs, litter, composting, vermicompost and the use of vermicompost for fertilizer in mangrove nurseries. The whole process is shown in Figure 4 below.

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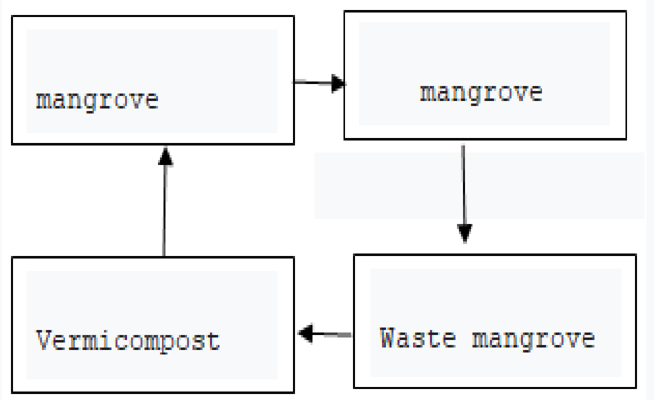

Fig 4. Circular economy of a mangrove nurseries

Using vermicompost as a plant fertilizer produces better quality plants than plants treated with chemical fertilizers. Linee et al.[22] reported that soil treated with NPK fertilizer produced 4.22 tons/Ha of cabbage, while vermicompost-treated soil produced 4.51 tons/Ha of cabbage. Likewise, tomatoes that were given NPK fertilizer reached a height of 37 cm, while those given vermicompost were 48 cm tall. Xiaoqiang et al.[23] compared the height and number of flowers on geranium and calendula plants treated with compost and vermicompost, respectively. The results showed that geraniums fed with compost reached a height of 39.98 cm, and the number of flowers was 1.8, while those treated with vermicompost reached a height of 54.74 cm and the number of flowers was 3.6.

The research results of Sanzidur and Basanta [24] showed that adding vermicompost produced 5.94 tons/ha of rice, higher than soil fertilized with NPK. Andi and Rosmarlinasiah[25]. reported that Gracillaria verrucosa seaweed plants treated with vermicompost could increase height, with a growth rate of 0.95-1.61% per day, increasing N, P, and K content. Using the circular economy concept in mangrove nurseries using vermicompost from mangrove waste can increase the productivity and quality of mangroves.

IV. CONCLUSION

Seaweed waste in the form of litter, leaves, and twigs is used as compost with the help of a bio activator, and then it is made into vermicompost with the help of L. Rubellus worms. The results of the psycho-chemical test showed a significant increase in the elements N, P, K and C/N ratio in vermicompost compared to compost. Using vermicompost as fertilizer for plants increases production improves quality and saves costs for fertilizer.

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