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Study of KOH uses in the Dried Seaweed Processing Factory *Eucheuma cottonii* at Jumpai Beach, Bali by SWOT Analysis

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Abstract. Seaweed is a marine product which contains a good source of minerals, vitamins, antioxidants, proteins, carbohydrates, phytochemicals, dietary fibers. Indonesia is the world's largest carrageenan seaweed producer. Potassium hydroxide (KOH) is widely used for extraction of Semi-Refined Carrageenan (SRC). SRC qualities and edible films developed can be significantly influenced by the concentration levels of KOH use in extraction. KOH treatment is also useful in the boiling process of *Eucheuma cottonii* to remove any matter except carrageenan and cellulose. This study aims to see how far KOH uses in the dried process of seaweed by quick screening test. The research was conducted at Jumpai Beach, Bali. The result shows the processing of *E. cottonii* in this factory uses ≥90% of KOH as a raw material (as evidenced by the numerous empty sacks of KOH 90% strewn around the site, as well as direct reports from workers. The average of a continuous concentration in different time of K^+ detected were 1000 ppm or 1% and 939 ppm or 0.939%, while the concentration of other elements detected was Cl with an average of a continuous concentration in different time were 759.3 ppm or 0.759% and 581 ppm or 0.581%. This indicates that this factory waste contains KOH and has the potential to pol- lute the environment. Furthermore, this method is very energy intensive, harmful to the environment, highly hazardous for human and must be carried out with increased caution due to the concentrated alkali solutions. The researcher concluded that new method should be found by using SWOT analysis.

Keywords: KOH, Seaweed, SWOT Analysis.

1 Introduction

One of the biggest incomes for over a million coastal people in Indonesia comes from seaweed farming. Seaweed industry has contributing to the country's rapidly expanding over the years especially during pandemic. Seaweed or macroalgae which is living in sea or brackish water has many benefits for human, animal and crop healthcare. Over 150 species of seaweeds are used as food worldwide [1]. This marine product contains a good source of minerals (e.g. calcium, magnesium, potassium, iodine, sodium, phosphorus, nickel, chromium, selenium, iron, zinc, manganese, copper, lead, arsenic, mercury and cadmium), vitamins (such as vitamin A, B1, B2, B3, B6, B12, C, D, E, pantothenic acid and folic acid), antioxidants, high value molecules like proteins, amino acids (both essential and non-essential amino acids), carbohydrates, phytochemicals, dietary fibers, omega-3 polyunsaturated fatty acids, terpenes, and pigments (carotenoids, chlorophylls and phycobilin's [2-8]. As a result, it has been suggested that seaweed polysaccharides contain a variety of seaweed biological activities and can enhance the overall strength and structure of food products. Different biological functions were demonstrated by macro- and micronutrient components extracted from seaweed, including sulphated polysaccharides, sterols, carotenoid pigments, and polyphenols. It has been researched against illnesses and pathologies that directly impact people, such as diabetes, hyperglycemia, cancer, metabolic disorders, aging, obesity, pathogenic diseases, bone-related disease and neurodegenerative and cardiovascular diseases [9].

Seaweeds or commonly known as sea algae is a microalga that grows naturally in coastal areas and has good resistance to salinity [10]. Seaweed is an important asset for the people of Bali, especially in Kemojan Island [11], Coastal area of Pandawa Beach [12], and Lembongan, Bali, both in terms of tourism and local community income because seaweed has many benefits for humans. For instance, seaweed contains bioactive compounds for dietary fiber such as sulphated polysaccharides, pep- tides, minerals, vitamins and fiber in order to against various disease which are not included by terrestrial plants in general.

Seaweed is also the most significant contributor to Indonesia's total aquaculture production which up to 80% of seaweed exports to China, South Korea and Vietnam [13]. In the early 1980s, most seaweed farming in Bali

has occurred in the Nusa Dua region and across the Badung strait-about 12 km long narrow sea strip that separates the mainland from the southern islands of Nusa Lembongan, Nusa Penida, and Nusa Ceningan, which fall within Bali's Klungkung regency, Jumpai Beach since its introduced. Klungkung regency is the location where 90 percent of Bali's seaweed was harvested since then. Based on Nabila's study, Bali Province can develop seaweed covering an area of 800 ha, and only 481 ha or 55% of it has been utilized [23]. The production from Eucheuma culture in Bali Province is around 73,899.40 MT. Those production has been obtained from an area of 179.1 hectares and has come from three main places, including Badung (5,070.00mt), Jembrana (39.40 mt) and Klungkung (68,790.00 mt and 73,899.40 mt) [14]. Based on data from tph marine fisheries office in 2018, seaweed production during the three years period started from 2013 to 2015 experienced a decline in production, from 175 tons to 129 tons, and continued to be pressed by developing tourism and human activities [24]. The farmers supply the seaweed and it proceed for almost a week, depending on the weather. Even the location is located in a smallest regency, it has been very well received by various seaweed farmers in Bali to improve their product since it has brought about positive eco- nomic outcomes. Seaweed has a very important value in this region because most of the seaweed production from Bali Province was marketed to other districts especially in Java (Jakarta and Surabaya), with the exception of Eucheuma which is exported. The trade in this commodity is able to accelerate the socio-economic development and create a wide spectrum of related economic activities for whole villages [15]. Based on the Packard Report (2018), seaweed employs approximately 3.3 million workers and most of them used traditional ways to process seaweed [13].

The world's largest carrageenan seaweed producer is located in Indonesia. Carrageenan is a strong binder for food proteins which is the high-value products of seaweed. It is a generic name of viscosifying and gel forming polysaccharides family. It can be extracted through alkaline treatment such as KOH and Ca (OH)2 and followed by KCL precipitation with lower percentage [13]. In fact, the process of cooking and drying Eucheuma cottonii in the Klungkung regency seaweed industry so far uses Potassium Hydroxide (KOH) ≥90% [16]. Based on previous survey, the liquid waste which produced in this process has no treatment before being distributed to the Jumpai offshore. Additionally, human activity around the factory also contributed beach pollution. This volume continues to increase in line with the increase of product order and population growth which lead to extremely volume of waste.

Indonesia is the second biggest seaweed producer in the world after China and the world's largest carrageenan seaweed producer. Demand for the seaweed extract carrageenan, used as a gelling agent in many processed foods, has been driving the growth. Potassium hydroxide (KOH) is widely used for extraction of Semi-Refined Carrageenan (SRC). SRC product is considerably easy and cheaper to produce as a natural polysaccharide hydrophilic in food and other product like cosmetic [17]. SRC qualities and edible films developed can be significantly influenced by the concentration levels of KOH use in extraction.

Although KOH could be used for extraction of SRC, the effect of waste water in the field of seaweed industry has spotted to be concern. Therefore, the study aims to overlook any positive prospects which can be used to protect the beach ecosystem in Klungkung, Bali.

2 Research Methods

Research on the Study of KOH uses in the dried seaweed processing factory *Eucheuma cotonii* at Jumpai Beach was carried out at PT Indonusa Alga Prima, Bali. The location of PT Indonusa Alga Prima is in Jumpai, Klungkung, Bali.

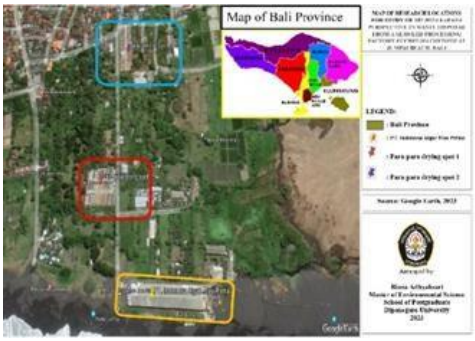

Fig. 1. Map of research locations.

Observation location coordinates:

1) PT Indonusa Alga Prima → Latitude: 8°34'27.97"S, longitude: 115°25'16.26"E
2) Para-para drying spot 1 → Latitude: 8°34'23.89"S, longitude: 115°25'12.32"E
3) Para-para drying spot 2 → Latitude: 8°34'16.91"S; Longitude: 115°25'12.52"E

The methods used in this research are first, descriptive qualitative (with primary and secondary data collection). Primary data collection is done by field observation and gathering data directly from the source. Methods include surveys, data collection, examination (both direct and lab purpose), interviews, observation, and focus groups discussion. Examination data is done by rapid screening using XD-Prime XRF. XD Prime can measure the concentration of elements in a product's paint and base material separately. This tool is ideal for quick screening and precise determination of toxic elements in water, cost-effective manner and does not require costly and time-consuming sample preparation. Secondary data collected by document review. Data gathered from published sources meaning that the data is already gathered by researcher and used for other purposes in a research as well [18]. The data obtained is then analyzed for the level of compliance with the regulations and legislation on waste management for industry. Qualitative research methods have been used by interview and observation [25]. Observation method is carried out by observing, evaluating, drawing conclusions, and providing comments on interactions that occur in the field [19]. Observations must be carried out directed, systematically, and on a scientific basis [20].

3 Results and Discussion

3.1 Results and Discussion

Seaweed processing industry processes raw seaweed material from the farmer into food and beverages. In this process, it produces high quantities of wastewater that contains residual chemicals that can pollute the environment around the factory, including KOH (Fig. 4 and Fig. 5).

Fig. 2. Effluent waste from seaweed factory.

POLLUTANT LOADS	UNIT	RESULTS		THRESHOLD LEVEL
		13.00 WITA	16.00 WITA	
pH	-	10.34	9.25	6-9
BOD	mg/L	97	121	30
COD	mg/L	217	290	100
TSS	mg/L	61	259	30
Amoniak	mg/L	0.03	0.08	10

Fig. 3. Pollutant loads between three hours gap.

The processing of seaweed (*Eucheuma cottonii*) in this factory uses ≥90% Potassium hydroxide (KOH) as a raw material (as evidenced by the numerous empty sacks of KOH 90% strewn around the site, as well as direct reports from workers). This concentrated KOH is highly hazardous and is used to boil the seaweed with water (Fig. 5. And Fig. 6.). By using HD-XRF, the average of a continuous concentration in different time (three hours gap) of K+ detected were 1000 ppm or 1% and 939 ppm or 0.939%, while the concentration of other elements detected was Cl with an average of a continuous concentration in different time (three hours gap) were 759.3 ppm or 0.759% and 581 ppm or 0.581%. This indicates that this factory waste contains KOH and has the potential to pollute the environment, especially sea water and the adjacent beach ecosystem. The results showed that the pH of the waste-water was 10.34 (03.00 WITA) and 9.25 (16.00 WITA). This indicates an alkaline pH almost certainly due to factory processing with KOH in the factory, exceeding the ideal pH value for sea water. A high concentration of KOH will cause the pH of the waste-water to shift towards alkaline and kill marine life and poison the beach ecosystem. As we can see in Fig. 4 this is worrying as the area supports a rural population at Jumpai Beach who depend on fishing for much of their livelihood.

Fig. 4. A Fisherman who captured fish at Jumpai Beach, Bali near a pipe exiting the rear factory wall directly onto the beach.

Fig. 5. KOH detection by XD-Prime XRF at 13.00 WITA

Fig. 6. KOH detection by XD-Prime XRF at 16.00 WITA

3.2 SWOT Analysis

SWOT Analysis is an analysis method used to evaluate four main points to evaluate the 'Strengths', 'Weaknesses', 'Opportunities', and 'Threats' involved in an organization, a project, a plan, a person or a business activity [22]. PT Indonusa Alga Prima has no treatment of seaweed waste management (Fig.2.). It can be seen in Fig. 2. when the effluent waste was observed to be discharged freely from a pipe exiting the rear factory wall directly onto the beach, or into the sea at high tide. As a result, it producing an offensive odor with brown-like grey foam pollution which is seen on Jumpai Beach from time to time. The material from a pipe was collected and analyzed. It found that pollutant loads are higher than threshold level. For example, in Fig. 3. sample which collected both in different times pH is counted passing through the threshold level by 10.34 (13.00 WITA) and 9.25 (16.00 WITA). Afterwards, the BOD level is tripled after the lunch time and it move upward sextuple. Furthermore, COD level counted around twice from the limit at the same day.

As we can see in the graph (Fig.7.) based on SWOT analysis, it was clearly found that the factory has four main strengths, first location which is strategic and has three branches including Jakarta, Malang and Bali. Bali is a special place to developing seaweed cultivation. Then, it has an enormous seaweed resource around the country. They also have good commitment to working effectively, professionally, efficiently to constantly provide customer satisfaction. Moreover, the factory has three legally certification, namely HACCP, HALAL and ISO9001. Furthermore, they have the two main best large products of carrageenan, namely Alkali Treated Cottony Chips (ATCC) and Alkali Threated Seaweed (ATS) for decades over Asia, Europe and South America.

On the other hand, there are the weaknesses which noted by researcher. Firstly, cultivation seaweed is depending in the weather. It can be decreased production when the weather is not fully supporting the seaweed farmer. Secondly, the hygiene system is so poor. We found that the factory is not clearly available to produce seaweed. Thus, waste water treatment, especially for KOH was not found. It could be dangerous not only for the ecosystem, but also for generation to generation. Moreover, the employees should be training well especially for K3 and waste-water treatment process.

For the opportunities, carrageenan could improve country income and it needed in human and animal purposes. At the end, the pollutant should be treated well before it flowed down into the sea.

4 Conclusion

Due to the waste-water's significant potential for environmental pollution and its KOH content, Jumpai Beach, Bali's seaweed cultivation has not yet fully complied with waste management rules and regulations. Additionally, the Jumpai Beach waste management procedure does not fully adhere to the regional regulations of Bali Prov- ince Number 11 of 2017-Bandega-and the laws and regulations pertaining to trash management.

Fig. 7. SWOT analysis of the seaweed factory.

The business should manage trash (including toxic and hazardous waste), energy, and natural resources sensibly and effectively. In order to determine whether or not the environment is environmentally friendly, the company should manage, monitor, and assess it as needed. The management of the organization can reduce the adverse effects on the environment by taking the essential measures. Thus, it is reasonable to anticipate occasional sustained advances. The Balinese then find it difficult to make decisions pertaining to the environment, society, and economics. The ecosystem will be gone if the Balinese and the local government do nothing.

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