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Production System Design Bio-Oil of Microalgae with POME as Raw Material For Media Cultivation

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Abstract

Palm Oil Mill Effluent (POME) produced by the Palm Oil Mill as a waste is now being used as a medium for cultivating microalgae for bio-oil raw materials. However, the bio-oil production process from POME raw materials is still limited to lab scale. Therefore, in this project, the analysis of bio-oil production system from microalgae for the development of existing production system. In this paper, the optimization model of bio-oil production from microalgae biomass is simulated into Digital Business Ecosystem (DBE) concept then analyzed to related stakeholders in system and interaction of each process between fellow stakeholders. And the results are defined in the form of Information Communication and Technology (ICT). The method used for this DBE concept is Unified Modeling Language (UML) which is use case diagram and Business Process Model and Notations (BPMN) diagram. And to predict an increase in yield by using ARM (Association Rule Mining). The results of this study are shown in the use case diagram and BPMN consisting of five communities, namely raw materials community, cultivation community, harvesting community, extraction community and quality control (QC). The process of production and storage of the resulting data is illustrated in the BPMN diagram. In this paper, the association rule is used to explore the relationship pattern between Cell Density attributes, Lipid Content and Light Intensity. The integration of association rule with a priori paradigm has succeeded in finding 34 rules with 11 valid rules top rank which have lift > 1 of the relationship between attributes.

Keywords: *Microalgae, Bio-oil, Palm Oil Mill Effluent (POME), BPMN, ARM*

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1. Introduction

The palm oil processing industry generates a lot of pollution from burning boilers as well as gases produced by liquid waste. As is known in the palm oil mill's effluent treatment in the ponds naturally will produce methane gas (CH_4) and carbon dioxide (CO_2). Both of these gases include the cause of global warming and climate change that is immersed simply evaporate in the air.

Indonesia is well known for making palm oil that can be a diverse range of palm oil biodiesel fuels, plasma plantations and palm oil to be self-sufficient in energy. Indonesia should see the potential for biodiesel development as an alternative that can be quickly implemented, judging by the abundance of raw materials for biodiesel manufacturing based on CPO, as well as biodiesel manufacturing technology, and certainly the most independent of energy [1]. In the large palm oil industry, many use Palm Oil Mill Effluent (POME) as a power plant. This is one way to reduce the greenhouse effect generated by the industry. Power plants using POME utilize methane gas (CH_4) into energy which leaves still wastes that are still rich in nutrients and CO_2 gas. Oil palm liquid waste has a very high organic content. In general, POME has a pH value of 4.72-5.38, while BOD values range from 1.2000 - 42.000 (mg/L) and COD

values between 16.000 - 66.000 mg/L. The ratio for BOD/COD for wastewater from oil palm mills ranges from 0.63 to 0.85. Palm oil waste also contains acidic organic compounds as a result of microorganism processes. The result of nutrient element analysis on palm oil liquid waste also shows the existence of nitrogen, phosphate and mineral elements such as Na, K Mg, Fe, Zn, and Cu [2].

Nutrition contained in the liquid waste can still be used as a source of nutrition for microalgae cultivation. Microalgae can act as a biofilter in minimizing the impact of environmental pollution caused by disposal of industrial liquid waste [3]. In addition to reducing the costs incurred for waste handling, the use of microalgae is one of the new alternative renewable energy sources. Microalgae can grow almost anywhere, requires sunlight and some simple nutrients, although growth rates can be accelerated by the addition of certain nutrients and sufficient aeration [4].

Several species of microalgae are being developed as bio-oil producers that can be further utilized into biodiesel [5]. Microalgae have potential as biodiesel feedstock because microalgae oil contains lipids suitable for use in the transesterification process [6]. uniquely, lipid compounds in microalgae are mostly composed of triglyceride compounds [7]. The preparation of bio-oil using microalgae feedstock itself generally consists of several processes such as media preparation and inoculum, cultivation process in POME media, microalgae harvesting process, filtering process until microalgae extraction process. From the process of making bio-oil with microalgae, raw materials are still often found some problems in the production process used such as less than optimal production time, the integration between the process is not good, and the resulting yield is not as expected.

To find solutions related to the above problems. It is necessary to model business process activities from the process of making bio-oil from microalgae raw materials. Where the business process model is created by using BPMN (Business Process Model and Notations) which is expected to provide a complete and detailed description of the activities related to the production process of bio-oil with microalgae raw materials. So as to optimize the production process and can increase the yield of the production process.

2. Material and Methods

The first step which is done to design a system is to define first the limitation of problems, goals, desirable and undesirable inputs, involved stakeholders, desirable and undesirable outputs, resources, rule, role, and the weakness of the system. The further steps analyze the needs and use case related to the human requirement by taking the attribute and entities system. The use case is used for the first time to make UML

BPMN stands for *Business Process Modeling Notation*, a new methodology developed by the Business Process Modeling Initiative as a new standard for business process modeling, as well as the design of complex systems such as messaging based (message-based) e-Business systems. This *bio-oil* production process in the BPMN 2.0 diagram to model the flow of processes and messages from the initial event to the end.

The associated analysis is also known as one of the data mining techniques that form the basis of various other data mining techniques. Particularly one of the stages of an association analysis called high frequent pattern mining captures the attention of many researchers to produce efficient algorithms. Association rule is a data mining technique for finding associative rules between a combination of items. The association rule is a statement of the implications of the X→Y form, where X and Y are disjoint items

and meet the requirements of $X \cap Y = \{\}$ [8].

3. Results and Discussion

3.1 Identification system

Identification of bio-oil production system from microalgae biomass begins by making input, process and output diagrams. Then determined the needs analysis and entities to build the system, such as stakeholders, input, output, rule, purpose, and role. Figure 1 Shows the construction of the system entities of the bio-oil production system from microalgae. The growth of microalgae requires nutrients already available in POME's liquid waste [9].

In the cultivation of algae added nutrients such as nitrates, phosphates, and silicates to meet the nutrients in the medium of cultivation [10]. The average pH for microalgae cultivation was between 7-8, with an average optimum pH ranging from 7.2-7.5 [11].

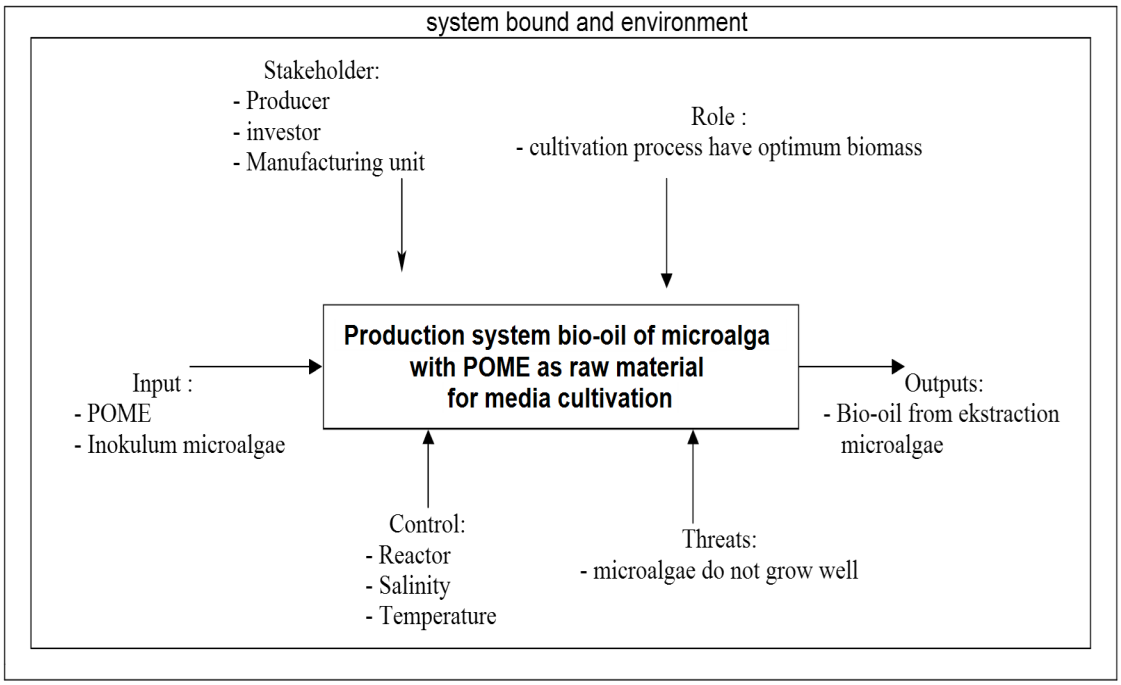

Figure 1

System entities of the bio-oil production system from microalgae

3.2 Business process analysis

The business process is one or more linked procedures or activities which aim to achieve overall business goals, usually in the context of an organizational structure that defines the functional roles and relationships. Use case and BPMN 2.0 are models that can help identify, define and describe the problem in a business process. The result of analysis processes described in Figure 2 for the use case and Figure 3. for BPMN which is a critical factor in producing bio-oil. And both of them have been validated.

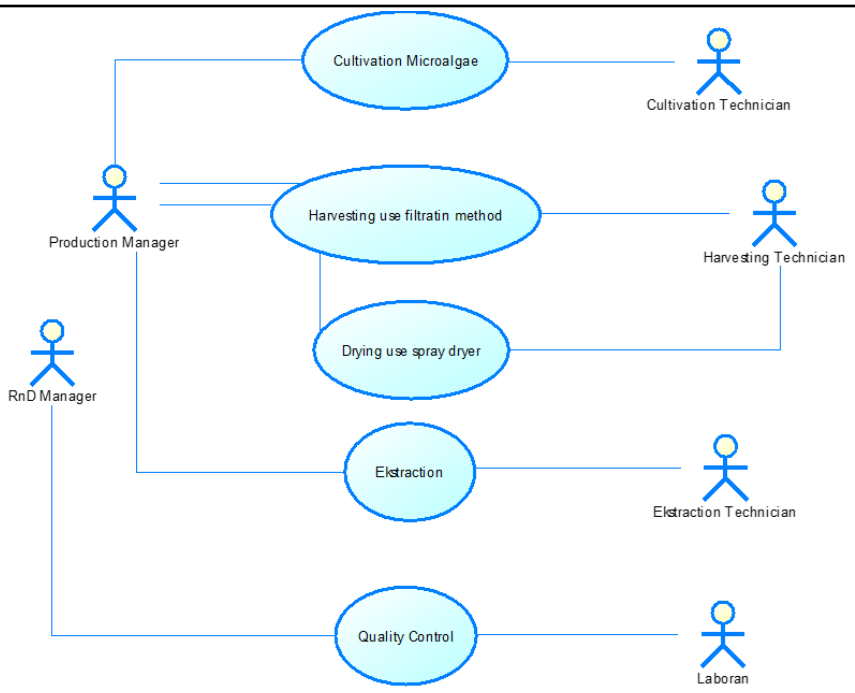

Figure 2

Use Case Diagram of the bio-oil production system from microalgae

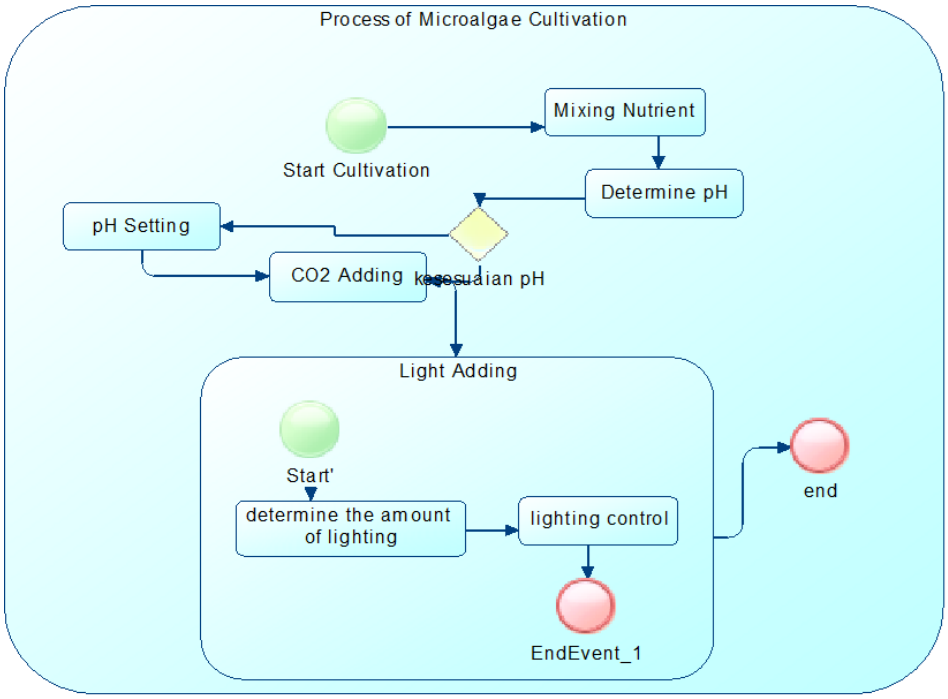

Figure 3

BPMN Diagram

3.3 Optimization use association rule mining (arm)

From the research data that has been done before, then do the optimization by looking at the association relationship between several variables on table 1 below.

Table 1
Indicator Mikroalgae Cultivation[12]

No	Light Intensity (lux)	Cell density (cell/ml)	Lipid Content (%)
1	1000	1965909	1141
2	2000	4382576	25778
3	3000	4844697	29796
4	4000	5117424	34235
5	5000	5375000	35077

The first step we must pre-process the data before converted to binary numbers, such as table 2

Table 2
Pre-Processing Data

Cell density (cell/ml)		Lipid Content (%)		Light Intensity (lux)	
distant	0 - 2500000	**low**	0 - 30000	**dim**	1000 - 2500
dense	2500000 - 5500000	**hight**	30000 - 40000	**bright**	2500 - 5000

From the data on table 2 then done optimization with ARM method and use Rapid Miner software. Then the results obtained from the combination of existing rules with the ratio of lift > 1 and is the top rank of Association Rule can be seen on the table 3

Tabel 3
The output from a result of data processing by ARM method.

No.	Premises	Conclusion	Support	Confidence	LaPlace	Gain	p-s	Lift	Conviction
4	high	dense	0.600	1	1	-0.600	0.120	1.250	∞
5	bright	dense	0.600	1	1	-0.600	0.120	1.250	∞
6	high	bright	0.600	1	1	-0.600	0.240	1.667	∞
7	bright	high	0.600	1	1	-0.600	0.240	1.667	∞
8	low	dim	0.400	1	1	-0.400	0.240	2.500	∞
9	dim	low	0.400	1	1	-0.400	0.240	2.500	∞
10	high	dense, bright	0.600	1	1	-0.600	0.240	1.667	∞
11	dense, high	bright	0.600	1	1	-0.600	0.240	1.667	∞
12	bright	dense, high	0.600	1	1	-0.600	0.240	1.667	∞
13	dense, bri...	high	0.600	1	1	-0.600	0.240	1.667	∞
14	high, bright	dense	0.600	1	1	-0.600	0.120	1.250	∞

And here are the Rules obtained from Association Rule Mining

Association Rules

[high] --> [dense] (confidence: 1.000)

[bright] --> [dense] (confidence: 1.000)

[high] --> [bright] (confidence: 1.000)

[bright] --> [high] (confidence: 1.000)

[low] --> [dim] (confidence: 1.000)

[dim] --> [low] (confidence: 1.000)

[high] --> [dense, bright] (confidence: 1.000)

[dense, high] --> [bright] (confidence: 1.000)

[bright] --> [dense, high] (confidence: 1.000)

[dense, bright] --> [high] (confidence: 1.000)

[high, bright] --> [dense] (confidence: 1.000)

4. Conclusion

To develop the production process into a larger scale required the interaction of various entities that interact in a system described on the use case diagram and BPMN so that it can be understood the flow of production processes and information exchange between stakeholders. In the process of production optimization using the Association Rule Mining (ARM) method generated as many as 34 rules are then validated and top rank produced as many as 11 Rule.

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