Development of A Methodology for Selection And Assessment of Liquid Waste Processing Technology From Oil Palm Industry Using Analytical Hierarchy Process (AHP)

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Abstract. The waste produced by the palm oil industry contributes a lot to environmental damage if it is not operated properly. Waste consists 70% of raw material amount which is almost half in the form of liquid. There are many alternatives for treating palm oil industry wastewater, from the most advanced technology to conventional technology. The difficulty in choosing and evaluating and applying the most appropriate technology for certain companies from various alternative technologies is a big problem. Therefore, a Decision Support System has been developed to assist in identifying, evaluating and selecting the best technology for wastewater treatment. In this study, three operations have been developed in MySQL, a database for waste treatment technology; Introduction of criteria using the Analytical Hierarchy Process (AHP) approach. The AHP method is also a proven tool for the decision-making process for selecting palm oil industry wastewater treatment technology. This model in the palm oil industry, therefore the software database can be updated and the program algorithm can be modified according to user needs. This study can assist in decision making and optimize the reprocessing of liquid waste from palm oil mills.

1. Introduction

The palm oil industry is an industrial sector that has great potential to be developed as one of the leading industries in Indonesia. In 2013 according to BP3-Dept data, the number of palm oil industries in Indonesia reached 320 units with various industrial production capacities. The total production of the palm oil industry in Indonesia is 13,520 tons of palm fruit bunches / hour. In addition to producing palm oil as the main product, the palm oil industry also produces waste produced in the form of liquid waste from the palm oil industry. The liquid waste of the palm oil industry consists of 96-96% water, 0.6-0.7% oil, 4-5% total solids consisting of 2-4% half solids [1].

Comparison of the amount of coconut produced by the two products is only 30% of the raw material. This means that 70% is industrial waste. The quantity of palm oil waste will increase along with the growth of the palm oil industry. The palm oil industry must have environmentally friendly waste treatment technology, low handling costs, and be able to provide added value to waste and can be used as a by-product of the palm oil industry. In the process of processing fresh fruit bunches into palm oil
will produce residual waste in the form of waste. The remainder of palm oil consists of solid waste, liquid waste and residual gas.

Technology is defined as "knowledge of how to do something". In the manufacturing industry, technology is the provider of the ability to allow an organization to provide goods and services to its customers, both now and in the future [2]. The purpose of selecting technology is to acquire new knowledge, components and systems in general technological capabilities. This will help companies make their products and services more competitive, have more effective processes, and / or create new solutions [3].

Measuring the sustainability of the technology for processing wastewater from the palm oil industry is a major problem and encourages discussion about the development of sustainable processing of wastewater. Developing assessment criteria and methods that provide sustainability measurement is a prerequisite for choosing the best alternative, identifying the requirements for wastewater technology in the palm oil processing industry, informing the integrated design of producers of alternative performances and the effects of social environmental monitoring.

The most common problem is the difficulty in implementing the most appropriate wastewater treatment technology from a series of alternative industrial wastewater treatment technologies in certain companies. Factors such as capital costs, operating and maintenance costs and area requirements are important considerations in the selection of waste oil treatment technology. Sustainability criteria also need to be included in the decision making process so that the right technology will be chosen.

Recent developments in waste treatment technology provide many options for waste treatment. Many technologies have been developed for waste treatment and the most widely used pond systems. Many other technologies have been developed that utilize various processing processes, both aerobic and anaerobic, highly mechanical non-mechanical, including composting systems, FAR (Fixed Anaerobic Reactor), pond systems, bribes, mulberries and others. The need for such decision support tools is very prominent in Indonesia because there is a large gap between oil palm waste and available waste treatment technologies. it will produce 5,678 million m3 of liquid waste per year, 1,135 million tons of mud and 1,865 million tons of fruit bunches.

On average, the palm oil industry can handle around 100 tons of fresh fruit bunches every day. In addition to the results that can be used, processing also produces various types of waste from oil palm [4]. Information about the application of various methods was obtained from four palm oil mills with a capacity of 30 tons of oil palm / hour and 60 tons of palm oil / hour and have applied one method of processing and using the remaining liquid waste. The following details about methods for processing wastewater include pond systems, composting systems and Fixed Anaerobic Reactors (FAR).

The choice of appropriate waste treatment technology enables sustainable development to be a challenge for national, regional and local policy makers. Technology selection and alignment involves decision makers who are critical of the profitability and growth of the company in an increasingly competitive global environment [5, 20-21]. In the process of selection and alignment it requires analysis of a large number of economic factors and analysis [6].

The method in the literature about the right decision-making activities is that decision makers use subjective judgment and their experience to choose the right technology. AHP is an organized multicriteria procedure for sorting out and examining complex choices dependent on numerous models [16]. AHP provides a methodological approach to decision-making problems that requires the accuracy of expert judgment to adequately assess existing technologies. Comparison of pairs compares criteria in pairs to evaluate criteria to be chosen, or has a greater number of values. AHP can deal with subjective and quantitative elements from dynamic cycle for all intents and purposes, methodically and quickly [17].

The decision support system that will be developed is expected to be used as a tool in selecting and evaluating wastewater treatment by palm oil industry operators. In developing decision-making tools for selecting waste treatment technology, several requirements have been identified. The system must be based on the web to allow users to access it via the Internet. The development uses MySQL 4.1.14. This system will be built in the form of a decision support system to optimize the use of liquid waste. It
is also hoped that the palm oil industry will be able to find out the value of the benefits that can be obtained from various methods of handling the entire industry. This is intended so that the value of using the entire industry operating method is not only reflected in the cost of implementation but also reflected in the value of the benefits to be obtained later.

2. Method
The Delphi method is a systematic and interactive method, which depends on the opinions and views of independent expert panels [7]. The questionnaire is a number of written questions that are used to obtain information from the respondent in the sense of reports about his person, or things he knows. The main purpose of making a questionnaire is to obtain information that is relevant to the research objectives [8]. Delphi is based on the principle that predictions from expert groups are structured more precisely than unstructured or individual groups. The experts carefully selected the questionnaire to select criteria for evaluating waste treatment technology in several rounds. After each round, expert options are provided for consideration. Therefore, experts are encouraged to review previous answers in groups sent by other members [9].

Analytical Hierarchy Process (AHP) is a method that uses hierarchically structured methods, a nine-point allotment scale, and a consistent ratio for calculating alternative weights and preferences for these criteria. First of all, we set goals in the matter. The second stage identifies criteria and sub-criteria for assessing alternatives. The third stage makes a hierarchical structure, which describes complex problems into various components and components into hierarchical forms. The fourth level collects data and studies expert information input models. We run comparisons in terms of partners and then examine consistency in the fifth and sixth respectively. In the seventh stage, we go to the consistency ratio, which must be between 0 and 0.1 [10-13, 18-19].

MySQL is an open relationship management system (relational database management system). Openly means that MySQL can be downloaded by anyone, both the original version of the program code and the binary version and can be used relatively free for both custom and computer programs. MySQL uses standard SQL language as a language that is interdependent in managing data. SQL tools are often also referred to as Queries. Because it uses the same standard language, it won't be a big obstacle if one day you connect to a database other than MySQL.

The object of the research observed was the processing of liquid waste from the palm oil industry. The variables used in the assessment of wastewater treatment were identified using the delphi method. Then the next variable is identified based on the most influencing criteria aspects. The variables contained in this study are:

- The dependent variable in this study is the assessment of wastewater treatment.
- Independent variables in this study are the criteria of economic aspects, environmental aspects, and technological aspects [14].

The steps taken in evaluating the processing of liquid waste from the palm oil industry are divided into 4 stages, namely:

- Survey stages
  To get qualitative data about existing technologies, such as criteria and subcriteria for determining the method for selecting and processing palm oil wastewater.
- Stage of criteria assessment
  To define criteria and subcriteria that have been obtained at the survey stage.
- Third Stage
  Stages of making design algorithms assessing and processing palm oil wastewater for decision making
- Fourth Stage
Implementation of criteria and algorithms designed on the decision making system that has been made.

Data collection in this study was carried out using questionnaires and questionnaires about determining criteria, sub-criteria assessment and selection of palm oil industry wastewater treatment. Steps to collect data in this case study. The stages of conducting research are:

- Preliminary study regarding problems found in the company.
- Preparation of questionnaires from review literature on waste treatment technology and technology selection over the past few years.
- Conduct structured interviews with experts using the Delphi method to obtain data on the technology of wastewater treatment [15].
- Making a decision system using the AHP method so that qualitative data and decision systems are obtained.
- Making MySQL Data Structure which contains datasets for processing palm oil industry wastewater.
- Implementing the problems found in the company
- Evaluate the effectiveness and efficiency of decision support systems.

Analysis and evaluation of problem solving can be obtained by obtaining criteria and sub-criteria, then making a decision system with the AHP method, after which the MySQL system dataset is created, then the implementation of the dataset that has been made with the company.

3. Result and Discussion

3.1. The Results of The Liquid Waste Technology Methodology

The technology of processing wastewater in the palm oil industry obtained 3 technologies for processing wastewater, including: FAR system, pond system, composting system. The following is the result of distributing questionnaires using the Delphi method.

**Table 1. Liquid waste technology data**

| No | Description                  | Waste Processing Technology |
|----|------------------------------|----------------------------|
|    |                              | RANUT | Pool System | Composting |
| 1  | Remaining Controlled         | Liquid | Liquid | Liquid |
| 2  | Area Requirement (Ha)       | -     | -       | 4 Ha (pool) dan 130 Ha (garden) |
| 3  | Cost of Investment Waste (Bilion) | 4,01 | -   | 0,04 |
| 4  | Laborers (people)           | -     | -       | 10 |
|    | Social Aspect                |       |         |       |
| 5  | Value Added as Fertilizer   | -     | -       | Available |
| 6  | Smell                        | -     | -       | Available |
| 7  | Waste Released              | -     | -       | Available |
| 8  | Quality Standards           | -     | -       | Available |
| 9  | Possible Pollution          | -     | -       | Available |
| 10 | Negative Social Impact      | -     | -       | Available |
| 11 | Value Added for IKS         | -     | -       | Not Available |
| 12 | Maintenance                 | -     | -       | Moderate |
|   | Description                                                                 | Value 1     | Value 2     | Status       |
|---|----------------------------------------------------------------------------|-------------|-------------|--------------|
| 13| Meet with Clean Production Programs                                         | -           | -           | Not Available|
| 14| BTS Capacity in FFS (ton / hour)                                           | 30          | 30          | -            |
| 15| Processing Hours (hour / day)                                               | 20          | 20          | -            |
| 16| Processing Days (day / year)                                                | 300         | 300         | -            |
| 17| Number of Processed BTS (ton / year)                                        | 180.000     | 180.000     | -            |
| 18| Percentage of SME Liquid Waste Generated from Tonnes of BTS Processed      | 60          | 60          | -            |
| 19| The Amount of SML Waste Generated by the SMEs (ton / year)                  | 108.000     | 108.000     | -            |
| 20| BTS converted to TBK (%)                                                    | -           | -           | -            |
| 21| Expulsion of TBK (ton TBK / year)                                          | -           | -           | -            |
| 22| Conversion of TBK to Composting of TBK (%)                                  | -           | -           | -            |
| 23| Estimation of Composting Stell (ton / year)                                 | -           | -           | -            |
| 24| Tam Capacity (liter / hour)                                                 | -           | -           | 18.000       |
| 25| Pumping Working Hours (hour / day)                                          | -           | -           | 8            |
| 26| Pumping Working Days (day / month)                                         | -           | -           | 8            |
| 27| Pumping Working Year (hour / year)                                          | -           | -           | 768          |
| 28| Requirement of SMD Liquid Discharge Processed per Hectare (liter / ha / month) | -           | -           | 166,622.59   |
| 29| Amount of SMI Liquid Application Processed Every Year (time / ha / year)    | -           | -           | 10           |
| 30| Tank Capacity (liter / hour)                                                | -           | -           | -            |
| 31| Daily Tank Tractor Work Hours (hour / day)                                  | -           | -           | -            |
| 32| Daily Tractor Tank for Month (day / month)                                 | -           | -           | -            |
| 33| Daily Tractor Tank for Year (hour / year)                                   | -           | -           | -            |
| 34| Operation Cost (Rp. / Year)                                                 | 978,971.982 | 257,728.955 | 65,494.333   |
| 35| Advantages of Used Waste with Area Use (Rp / LCIKS ton)                     | 2,933       |             |              |
| 36| Advantages of Used Waste with Boiler (Rp / LCIKS ton)                       | 8,075       |             |              |
| 37| Advantages of Used Waste with IPAL Area (Rp. / Year)                        | 99,000,000  |             |              |
| 38| BTS Converted to TBK (%)                                                    | -           | -           | -            |
3.2. Liquid Waste Technology Evaluation Criteria and Sub-criteria Results
Selection criteria and sub-criteria have been conducted by interviewing experts in the criteria of liquid waste treatment technology and sub-criteria are considered to have an effect on the alternative liquid processing technology. An interview summary with sub criteria for selection and criteria for liquid material assessment technology can be shown in Table 2.

| No. | Criteria          | Sub criteria                  |
|-----|-------------------|-------------------------------|
| 1   | Economic Aspect   | Installation cost             |
|     |                   | Maintenance cost              |
|     |                   | Operation cost                |
|     |                   | SM Cost                       |
| 2   | Environmental Aspect | Waste Quality Value          |
|     |                   | Sludge levels                 |
|     |                   | Release stage                 |
| 3   | Technology Aspect | Performance                   |
|     |                   | Maintenance                   |
|     |                   | Human resources               |
|     |                   | Area                          |
|     |                   | Resistance                    |
|     |                   | User friendly                 |

3.3. The Result of Liquid Waste Treatment Technology Hierarchy Structure
The hierarchical structure results based on the criteria and sub-criteria obtained, three criteria and thirteen sub-criteria were selected. The Hierarchical Structure results can be seen in Figure 1.

3.4. Result of System Decision Making with MySQL Software
The selection model for the palm oil industrial waste treatment technology consists of fourteen sub-models to be selected in the MySQL software and used as a dataset.
3.5. Criteria and Sub-criteria Weight Results
AHP is used to get the weight of each criterion, sub-criteria, and alternatives. The first step is to do calculations using the geometric average of the data provided by all group members totaling 5 respondents.

\[ GM = \left( X_1 \cdot X_2 \cdots X_5 \right)^{1/5} \]  

The results of the weighted subcriteria can be seen in Figure 6.

![Figure 6: Results of weight criteria and sub-criteria liquid waste treatment technology](image)

From the result of calculation of criterion weight and sub-criteria obtained economic criteria criterion have biggest weight which is 0.4134 so that criterion can be used as biggest aspect of assessment in choosing liquid waste treatment technology. While the sub-criteria of area has the biggest weight that is 0.0661 so that sub-criteria can be used as consideration in selecting liquid waste treatment technology.

4. Conclusion
In the assessment of Palm Oil wastewater treatment technology, the decision support system uses the Process Hierarchy Analysis (AHP) algorithm to help determine the choice of better liquid waste treatment technology based on the goals, criteria, sub-criteria and alternatives.

In data processing is used in the MySQL database to store a list of data for each alternative sub-criteria option. This program is considered to represent an alternative option of liquid waste treatment technology that is qualitatively based on data from experts. Database is developed from data collected from subdivision of liquid waste treatment of each type of palm oil industry.

Developing software can be created. In the design used in the phpMyAdmin interface, the MySQL database. The company needs a system that can simplify the selection of liquid waste treatment technology.
technology to address the problems that occur until there is no regulatory standard and criteria. There are 3 criteria of liquid waste treatment technology used in selecting the best processing technology and the best decision-making method is Analytical Hierarchy Process (AHP). To facilitate the implementation of this system, a program designed for the web can be used by companies in determining the best processing technology.

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