Identification criteria and indicators of palm oil industrial solid waste processing technology

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Abstract. The palm oil industry continues to grow from year to year — processing of the palm oil industry into Crude Palm Oil (CPO) and Palm Kernel Oil (PKO). The ratio of the amount of oil produced by both products is 30% of the raw material. This means that 70% is palm oil waste. The amount of palm oil waste will increase in line with the development of the palm oil industry. The amount of waste generated by the palm oil industry if it is not handled properly and effectively will contribute significantly to environmental damage. Industrial activities ranging from raw materials to produce products will disrupt the lives of people around the factory. There are many alternative technologies available to process other industries, but problems that often occur are difficult to implement the most appropriate technology. This paper describes an application of multiple criteria analysis (MCA) in assessing criteria and indicators of palm oil industrial solid and liquid waste. These methods were used in a participatory decision-making environment where a team representing various stakeholders and professionals used their expert opinions and judgments in assessing different criteria and indicators (C&I).

1. Introduction

The production of the palm oil industry in Indonesia grew rapidly from 27,782,004 tons in 2013 to reach 35,359,384 tons in 2017. The growth rate of the production of the palm oil industry in Indonesia reaches 6.22% per year. The palm oil industry continues to grow from year to year. The palm oil industry processes palm oil into Crude Palm Oil (CPO) and Palm Kernel Oil (PKO). The comparison of the coconut quantity produced by both products is only 30% of the raw material. This means that 70% is industrial waste. In the production process, palm oil will contribute significantly to the processing of palm oil mills at boiling stations and destruction stations. In addition to producing products, palm oil processing also produces various types of waste, one of which is solid waste. The amount of palm oil mill effluent will increase as the palm oil mill grows. Oil palm fruit bunch processing (FFB) for palm oil production produces several types of waste. The oil extraction and cleaning processes in the factory produce palm oil mill effluent (POME). In the extraction of palm oil, three main processes produce POME, among others: sterilization process, crude palm oil clearance process, which is extortion, separating and clarifying the sterilization of empty fruit bunches. The palm oil mill produces 0.7-1 m³ of POME for every ton of freshly processed fruit bunches. The newly generated POME is generally hot (600-800°C), acidic (pH 3.3-4.6), thick, brownish with solids, oils and fats, chemical oxygen demand (COD) and biological oxygen demand (BOD) tall one. Palm oil mill waste is a colloidal suspension consisting of 95-96% water, 0.6-0.7% oil, a total 4-5% solid waste comprising suspended solids of 2-4% [1]. The palm oil mill effluent contains organic materials of...
BOD, COD, oils and fats, solid waste in varying amounts [2]. Organic materials found in wastewater cause environmental damage if waste processing technology is not available. The most common problem with choosing palm oil processing technology is that it is difficult to apply the most appropriate technology from a range of palm oil processing alternatives to a particular company. Factors such as capital costs, operating costs, maintenance, and land use, are important considerations in the choice of oil waste processing technology.

Developing assessment criteria and methods that provide sustainability measurement are a prerequisite for choosing the best alternative, identifying palm oil industry's processing technology requirements, informing the integrated design of alternative show manufacturers and the effects of social, environmental monitoring. The diversity of criteria and the latest gauges in this rapidly expanding field demonstrates the importance of conceptual work and methodology in this area. Development and selection of criteria require parameters relating to reliability, suitability, practicality and size limits. Many of the weak technologies developed by the technological options are difficult because there is no database and technology valuation method. Database development can facilitate the search and identification of waste processing technologies.

2. Method
The first phase of the study was to collect questionnaires through literature reviews derived from books, references, international journals, websites related to other palm oil industries, waste-processing technologies, decision making, and technology selection over the last period. Surveys were conducted to obtain the availability of palm oil mill processing technology. Data obtaining on waste processing technology is done using interview techniques designed for guided interviews with members involved in the formulation of this system problem using the Delphi method. The experts involved in the Delphi process were identified in personal knowledge and literature review. A literature review is created to find the right criteria for waste technology. Information on these criteria is obtained from published journals and from stakeholders, as well as from expert knowledge. The results are expected to include criteria and indicators for waste technology. Created a literature review to find criteria appropriate to waste processing technology. The research method can be seen in Figure 1.
3. Result and discussion

3.1. Delphi Results
Below is a table showing the percentage of answers on the questionnaire being seen in five experts who are proficient in their respective fields. The Delphi Result can be seen in Table 1.

3.2. Results of Solid Waste Processing Technology
Selection criteria and sub-criteria conducted by interviews with experts in solid waste processing technology against criteria and subcriteria are considered to be influential on alternative waste processing technology alternatives. The stages of this study are the determination of the criteria and sub-criteria of waste processing technology assessment. The summary of the vacancy meeting was the selection criteria, and the sub-criteria of the assessment of solid waste processing technology can be shown in Table 2.
Table 1. Results delphi survey

| Questionnaire                                           | Percentage | Agreed |
|---------------------------------------------------------|------------|--------|
| There is the right technology                          | 7.53       | 5      |
| Eco-friendly products                                   | 6.27       | 5      |
| Pollution levels are low                                | 6.27       | 5      |
| The maintenance of nature around life                   | 6.27       | 5      |
| Higher profit                                           | 6.02       | 4      |
| Security reassignment                                   | 6.02       | 4      |
| Arrange clear rules or regulations                      | 6.02       | 4      |
| Can provide input to be used for the palm oil industry  | 5.02       | 5      |
| There is no social conflict                            | 5.02       | 4      |
| Enough physical infrastructure                          | 5.02       | 4      |
| Access to information and data                          | 5.02       | 4      |
| Public welfare                                          | 4.52       | 4      |
| The use of sources is around optimally and non-polluting| 4.52       | 4      |
| Low waste management cost                               | 4.52       | 3      |
| Facilities or infrastructure are adequate                | 4.52       | 3      |
| The existence of a network of academics with business and government | 4.02 | 4 |
| Increase in foreign exchange                            | 3.39       | 3      |
| Trustor community support                               | 2.51       | 2      |
| Processing equipment tray                               | 2.51       | 2      |
| Clean water                                             | 2.51       | 2      |
| Support from donor agencies                             |            |        |
| **Total**                                               | **100.00** | **78** |
Table 2. Solid waste processing technology criteria and sub-criteria assessment

| Criteria                        | Sub - Criteria                        | Explanation                                                                 |
|---------------------------------|---------------------------------------|-----------------------------------------------------------------------------|
| Environmental                   | CO₂ emissions                         | CO₂ content found in waste                                                  |
|                                 | Energy usage                          | The energy used to support transformation activities                       |
|                                 | Residual integration                  | Integration of several oil palm waste treatment technologies and interconnections with one another to increase added value from waste technology processing |
| Environmental                   | Energy efficiency                     | The most frequently used criteria for assessing technology and usage systems |
|                                 | Emission Level                        | Reducing the emission levels of greenhouses to reduce the environmental impact of fuel consumption |
| Technology                      | Technology maturity                   | Technology readiness in processing waste                                   |
|                                 | Technological development efforts      | Evaluation of related technology as an effort for future development        |
|                                 | Technology industry support            | Prescribed as a capability in which technology linkages or industry support can be sought during the development of solid waste bunk processing plant technology |
|                                 | Ease of operation                     | Ease of use of technology by operators in processing waste                  |
|                                 | Failure Rate                          | Percentage failure of technology in processing waste                       |
| Performance                     |                                       | The capacity of palm oil solid waste processing technology regarding producing optimum output and input in system use |
| Maintenance                     |                                       | Technology capability can be treated                                       |
| Human resources                 |                                       | Sufficient human resources for technology development                      |
| Industrial support              |                                       | The capabilities in which technology linkages or industry support can be sought during the development of empty fruit bunches solid waste processing technology |
| Resistance                      |                                       | Resistant technology                                                       |
| Economy                         | Initial investment                    | Cost of industrial facilities and facilities required for technological solid waste processing |
|                                 | Operation cost                        | The costs incurred in the process of processing solid waste of empty fruit bunches |
|                                 | Maintenance cost                      | The costs incurred in the process of processing solid waste of empty fruit bunches |
|                                 | Human Resource Cost                   | Costs incurred for recruiting human resources                               |
| Social                          | Area usage                            | The proportion of the area is needed for the empty fruit bunches solid waste processing technology |
|                                 | Social acceptance                     | Set as if the system is safe for people and people                          |
|                                 | Technological impact                  | Empty waste processing of solid waste bunches does not pollute the environment and disturb the community |

4. Conclusion
On the quest for critique has been found Criteria that can be used as sustainability of the selection of waste processing technology; among others there are 22 criteria from 4 fields, namely energy consumption, waste integration, energy efficiency, emission level, technology development efforts, performance, maintenance, human resources, industry support, initial investment, operating cost, maintenance cost, human resource cost, use area, social acceptance, and technological impact.
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