Analyze the Environment and Economic Impact of Vegetable Tanning Agents Selection

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Abstract—The selection of vegetable tanning agents is important in tanning industry because they can generate environmental and economic impact. Environmental effect such as contaminating fresh water aquatic ecotoxicity and human toxicity is the problems of tanning industry. Based on economic aspect, the price and saving cost is the effect of the use of vegetable tanning agent. This research was conducted to analyze the impact of vegetable tanning agents selection based on environmental and economic aspect. To evaluate the impact of environment, the simulation software was used. The fuzzy multi-attribute decision making was also used to selection process to find the best vegetable tanning agents based on environmental and economic aspects.

Keywords—Tanning, Life Cycle Assessment, Fuzzy.

I.   INTRODUCTION

The manufacturing industry has a significant contribution based on economic, employment, and investment. One of manufacturing industry that has a significant contribution is tanning industry. Even in Mediterranean countries, tanning industries has became the most important industry [3]. It has been estimated that 1.67×10^9 m^2 of leather is being made annually in the world [2]. Global trade of leather products approximately US$100 billion per year [11]. However, tanning industry has a major problem [10]. The problems of tanning industry such as [8] said that tanning industries is considered as one of the most pollutant industry in the world. [6] mention that pollution, toxic chemical release, and greenhouse gas (GHG).

The tanning process of leather is important because it can increase the reliability of the leather, such as to prevent of spoilage and increase the resistance to chemical degradation. In conventional tanning industry, the agents of tanning process used are chromium, aluminum, titanium zirconium [1]. The conventional tanning process contribute higher negative impact on environment and human body. The better tanning process is vegetable tanning process. On vegetable tanning process, the material used are organic and vegetable materials [11].

Absolutely vegetable tanning process is better than conventional tanning based on environmental aspect.

However, vegetable tanning agents is also need to be calculated their impact to environment, because [9] said that the wastewater pollution actually caused by material that is not absorbed perfectly by the tanning process. This research conducted on vegetable tanning industry, so the tanning process has been use the vegetable agent. This study evaluated the environment impact and economic contribution. Vegetable tanning agents evaluated in this research are mimosa, gambier, and indusol. The environmental aspect scope on this study is consist of fresh water aquatic ecotoxicity and human toxicity.

To evaluate the impact of vegetable tanning agents is used lice cycle assessment. The selection of vegetable tanning agents used is fuzzy multi-attribute decision making (FMADM) approach, because in the selection process found several criteria that need to be considered by decision-maker. Fuzzy multi-attribute decision making (FMADM) is used to help the decision maker to find the best vegetable agents. [7] and [5] said that fuzzy has proven very useful to deal with uncertainty and ambiguity. In this research, uncertainty referred to the lack of information regarding the environmental impact and the absence of reference to be used as reference criteria. In a lot of complex decision making problems, informed decision making is often imprecise or uncertain because of time pressure, lack of data, or limited attention, and decision makers ability to process the information [4]. By using fuzzy multi-attribute decision making (FMADM), inaccuracy and uncertainty of the information can be described well to find the best agents.

II.   METHODOLOGY

On this research, the methodology is consist of two stage, these are the calculation of life cycle assessment and decision making process.

2.1   CALCULATION OF LIFE CYCLE ASSESSMENT (LCA) VALUE.

The assessment of vegetable tanning agents is calculated by using simulation software. The simulation software that used in this research is openlca software. The process started by making the flow process and input the material. The result of this calculation were the impact of each

vegetable tanning agents on several factors, such as fresh water aquatic ecotoxicity and human toxicity.

2.2 DECISION MAKING PROCESS

Decision making process of this research is used fuzzy multi-attribute decision making. Because of there are several criteria, the questionnaires is used to weighting process. The weighting criteria of this research are fresh water aquatic ecotoxicity, human toxicity, and price. The calculation is using Eq. (1).

$$r_{ij} = \begin{cases} \frac{X_{ij}}{Max\ X_{ij}}, if\ j\ is\ benefit\ atribute \\ \frac{Min\ X_{ij}}{X_{ij}}, if\ j\ is\ cost\ atribute \end{cases} \quad (1)$$

Where r_{ij} is the normalized performance rating of alternatives A_i on attribute C_i: i= 1, 2, 3 …, m. Alternative preferences value (V_i) is given as greater V value which is mean the alternative A_i is selected.

III.   RESULT AND DISCUSSION

Life cycle impact assessment of mimosa, gambier and dulcotan are callculaten using impact assessment simulation software. The software used in this study is openlca. The software simulation evaluate the impact of each vegetable tanning agents. From the calculation value, the comparison between vegetable tanning agents can be made. Impact assessment calculation result of vegetable tanning agents to fresh water aquatic ecotoxicity and human toxicity shown in table 1. Table 1 consist of reference unit where it is based on international standard and impact assessment value. The impact category of this research focus in fresh water aquatic ecotoxicity and human toxicity because they are the most dangerous impact that directly contaminated the human life. In another side, fresh water aquatic ecotoxicity and human toxicity have the highest value of impact assessment than others impact categories.

Table.1: Impact assessment comparison value of mimosa, indusol, and gambier

Impact category	Value			Reference unit
	Mimosa	**Indusol**	**Gambier**	
Freshwater aquatic ecotoxicity - FAETP 100a	18.002	11.123	12.974	kg 1,4-DCB-Eq
Human toxicity - HTP 100a	11.702	2.4872	9.4462	kg 1,4-DCB-Eq

After the result of each vegetable tanning agents calculated. Then, the comparison of each vegetable tanning agents to fresh water aquatic ecotoxicity and

human toxicity created. The comparison graphic is made to show the graphic of vegetable tanning agents and to simplify the comparison between three vegetable tanning agents. The comparison graphic is shown in figure 1. Based on figure 1, indusol has the lowest impact than others, simply, indusol is the best vegetable tanning agents based on environmental aspect.
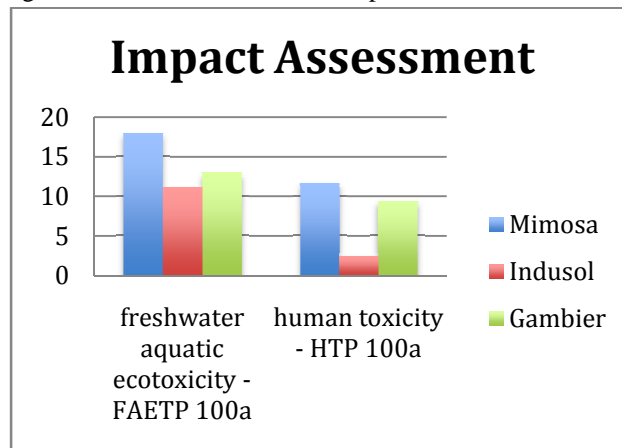

Fig. 1: Impact Assessment Comparison of Mimosa, Indusol and Gambier

Then, fuzzy multi attribute decision making is used to find the best vegetable tanning agents by considering economic aspect. Fuzzy multi attribute decision making process is used in this research because there are trade off between environmental and economic impact. This process start with weighting process. Weighting obtained from questionnaires. Then next process is normalization using equation 1. Vector is result of multiplication normalization and weighting. The value of vector is shown in table 2.

Table.2: Vector Calculation Value

Criteria		Price	FWAE	HT
Weighting (W)		0.75	0.75	0.75
Vector	**Mimosa**	0.5	0.375	0.5
	Indusol	0.75	0.75	0.75
	Gambier	0.5	0.75	0.5

The rank of the best vegetable tanning agents can be selected by rank of the highest value. The rank is the total sum of vector value each vegetable tanning agents, as shown in table 3.

Table.3: Ranking of Vegetable Tanning Agents

Vegetable Tanning Agents	Value	Rank
Mimosa	1.375	3
Indusol	2.25	1
Gambier	1.75	2

Based on table 3, indusol is the best vegetable tanning agents based on fresh water aquatic ecotoxicity, human toxicity, and price. It means that indusol as the best vegetable tanning agents by consider environmental and economic aspects.

Table.4: Sensitivity Analysis

Vegetable TanningAgents		Mimosa	Indusol	Gambier
Existing		1.375	2.25	2.75
Vector Value	+5%	1.08	1.77	1.38
	-5%	0.98	1.60	1.25
Vector Value	+10%	1.13	1.86	1.44
	-10%	0.93	1.52	1.18
Vector Value	+20%	1.24	2.03	1.57
	-20%	0.82	1.35	1.05
Vector Value	+30%	1.34	2.19	1.71
	-30%	0.72	1.18	0.92

To ensure the data calculation that the relative importance given by decision makers in weighting process, the sensitivity analysis is conducted. The sensitivity analysis is shown in table 4. Sensitivity analysis test begins with the addition an subtraction of 5% to 30% each weighting process. Sensitivity analysis can find out the change of value. However, the result of sensitivity analysis of this study is no change of rank order. It means that indusol still be the best vegetable tanning agents based on this research.

IV. CONCLUSION

This research indicates that vegetable tanning is better than conventional tanning. However, vegetable tanning process need to be selective in select vegetable tanning agents to find the agents that has the lowest negative impact to environments and economic. From the result, indusol selected as the best vegetable tanning agent because it has the lowest negative impact on fresh water aquatic ecotoxicity and human toxicity. But, the price of indusol is higher than other. Because of the tradeoff between environmental and economic aspect, fuzzy multi-attribute decision making (FMADM) need to be conducted to find the best agents by considering environmental and economic aspect. Based on fuzzy multi-attribute decision making (FMADM) process, indusol selected as the best vegetable tanning agents. This study shows that vegetable tanning agents also has a significant and determining factors to amount of impact on the fresh water aquatic ecotoxicity and human toxicity. For further research, several factor such as availability of vegetable tanning agents need to be considered, because some vegetable tanning agents are difficult to be obtained in several country, even need to be imported, so the sipping cost will increase the cost of purchasing. For the environmental factors, climate change, acidification potential and some impact categories other can be considered.

REFERENCES

[1] E. M. Brown, M. M. Taylor. Essential chromium? *Journal of the American Leather Chemist Association,* 98 pp 408-414. 2003

[2] FAO. World Statistical Compendium for Raw Hides and Skins, Leather and Leather Footwear 1982-2000. Food and Agriculture Organization of the United Nations, Rome.2001

[3] G. H. Insel, E. Görgün, N. Artan, D. Orhon. Model based optimization of nitrogen removal in a full scale activated sludge plant. Environmental Engineering Science 26 pp 471-480. 2009

[4] G. J. Klir, "Uncertainty and information: foundations of generalized information theory," Wiley-Interscience, Hoboken, NJ, 2006

[5] H. Bustice, F. Herrera, J. Montero, "Fuzzy sets and their extensions: representation, aggregation and models," Physica-Verlag, Heidelberg, 2007

[6] Kuo-Wen Chen, Lung-Chieh Lin, Wen-sing Lee. "Analyzing the carbon footprint of the finished bovine leather: a case study of aniline leather," Energi Proceedia Vol. 61pp. 1063-1066. 2014

[7] K. Atassanov, "Intuitionistic fuzzy sets, theory and applications," Physica-Verlag, Heidelberg, 1999.

[8] Mannucci, Alberto., et al., 2010. Anaerobic Treatment of Vegetable Tannery Wastewaters: A Review. *Desalination*, 264 pp 1-8. 2010

[9] M. Lasindrang, H. Suwarno, S. D. Tandjung, H. N. Kamiso,. "Adsorption pollution leather tanning industry wastewater by chitosan coated coconut shell active charcoal," Agriculture and Agricultural Science Procedia Vol. 3 pp. 241-247, 2015

[10] S. Alfarisi, S. B. Sutono, W. Sutopo. Evaluate the use of tanning agent in leather industry using material flow analysis, life cycle assessment and fuzzy multi-attribute decision making (FMADM). Proceeding on annual conference of industrial and system engineering, F6-F9. 2016.

[11] S. M. Mavlyanov, et al. Vegetable tanning agents. Chemistry of Natural Compounds 37 , 1-24. 2001

[12] UNIDO, "Future trends in the world leather and leather products industry and trade," United Nations Industrial Development Organization, Vienna, 2010.