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Submission date: 29-Aug-2019 11:25AM (UTC+0700)
Submission ID: 1164692986
File name: ning_agent_in_leather_industry_using_material_flow_analysis.docx (78.44K)
Word count: 2235
Character count: 12448

Evaluate the Use of Tanning Agent in Leather Industry Using Material Flow Analysis, Life Cycle Assessment and Fuzzy Multi-Attribute Decision Making (FMADM)

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Abstract. Tanning industry is one of the companies that produce many pollutants and cause the negative impact on the environment. In the production process of tanning leather, the use of input material need to be evaluated. The problem of waste, not only have a negative impact on the environment, but also human health. In this study, the impact of mimosa as vegetable tanning agent evaluated. This study will provide alternative solutions for improvements to the use of vegetable tanning agent. The alternative solution is change mimosa with indusol, gambier, and dulcotan. This study evaluate the vegetable tanning of some aspects using material flow analysis and life cycle assessment approach. Life cycle assessment (LCA) is used to evaluate the environmental impact of vegetable tanning agent. Alternative solution selection using fuzzy multi-attribute decision making (FMADM) approach. Results obtained by considering the environment, human toxicity, climate change, and marine aquatic ecotoxicity, is to use dulcotan.

INTRODUCTION

Leather tanning is a wide common industry all over the world. It is known to be one of the most important industries in Mediterranean countries [7]. It has been estimated that about 1.67 109 m2 of leather is being made annually in the world [6]. Leather industry, an age old enterprise provides a wide range of consumer goods such as shoes, garments, bags, and others by turning the food industry's waste product into a desirable, useful and sustainable range of end products [1]. Leather products have a prominent role in world economy, which estimated global trade approximately US$100 billion per year [12].

Leather tanning industry contributes a significant role to improve the economy, investment, and employment. However, tanning industry activities have a major problem. Leather Industry is characterized as industries which produce high strength toxic chemicals [5]. The waste which is produced, cause a negative impact on the environment and humans. The main issues of leather industry are pollution, toxic chemical released, and greenhouse gas (GHG) [4]. So, the waste is concerned to wastewater that containing hazardous toxic. Actually, the wastewater pollution caused by material that is not absorbed perfectly by the tanning process, so the wastewater contains of hazardous material [9]. Since the transformation process of raw materials into products that occur in the water (the average water consumption in the tanning process is between 25 to 80 m3 per tonne of raw material) proved that the main burden of pollutants is in the waste water. In this research, vegetable tanning process conducted by using mimosa as the main agent. Mimosa (mimosa extract) as a tanning agent is an extract of the bark of acacia (Acacia deoureus) that has been

3rd International Materials, Industrial and Manufacturing Engineering Conference (MIMEC2017)
AIP Conf. Proc. 1902, 020053-1–020053-5; https://doi.org/10.1063/1.5010670
Published by AIP Publishing. 978-0-7354-1590-4 /$30.00

processed with chemical material. Acacia bark is one of the vegetable tanning material that contain 63% of tannin [11].

This study evaluated the impact contribution to the environment by several factors that considered such as fresh water aquatic, human toxicity, climate change, and marine aquatic ecotoxicity. To analyze the material flow diagram that occurred during the production process, used material flow analysis (MFA) approach. To find out and evaluate the impact on the environment, used life cycle assessment (LCA) approach. Alternative solutions for the improvement of this research is to replace the vegetable tanning agent with others. Vegetable tanning agents that will be proposed for improvement alternative are indusol, Gambier, and dulcotan. Selection of the three alternative proposals is related to tannins material contained.

In the proposed improvements, certainly there are some criteria that need to be considered by the decision makers. To help decision-makers to determine the best solution, used concept of fuzzy multi-attribute decision making (FMADM), because, according to [2] and [3] fuzzy has proven very useful to deal with uncertainty and ambiguity. Uncertainty and lack of clarity in this study referred to the lack of information regarding the environmental impact of the application of vegetable tanning methods and the absence of reference to be used as reference criteria need to be the most important factor in selecting the best alternative vegetable tanning agent. According to [8], in a lot of complex decisions making trouble, informed decision-making is often imprecise or uncertain because of time pressures, lack of data, or limited attention and decision-makers ability to process the information. While the concept of multi-attribute decision making is in addition to the development of a fuzzy concept. So, by using fuzzy multi-attribute decision making approach, decisions can be made by selecting the best alternative of several available alternatives. Thus, fuzzy multi-attribute decision making (FMADM) is an approach that is suitable to describe the inaccuracy and uncertainty of the information and make decisions by choosing the best available alternatives.

METHODOLOGY

Methods of this study consist of three stages, these are the calculation of material flow analysis, life cycle impact assessment calculations using openlca version 1.4.1, and the selection of the best alternative solutions using FMADM approach.

A. The First Stage : Calculation of Material Flow Analysis (MFA)

The calculation of material flow analysis are to calculate the amount of material consumption required to support the production process. Mathematical equation used is :

$$M = \sum_{i=1}^{n} Mi + \sum_{i=1}^{n} Wi \tag{1}$$

where i= process number (1, 2,.... , n)

B. The Second Stage: Calculation of Life Cycle Assessment (LCA) Value

At this stage, started by making the flow process, insert the value input material consumption that has been obtained from the calculation of material flow analysis and the value of output produced, and also determine the type of process that occurs in openlca software version. The results of this calculation is the impact value of each vegetable tanning agent based on impact categories.

C. The Third Stage: Decision Making

In this study, simple additive weighting (SAW) method is used in decision making process. Questionaries is used as input of weighting process. The weighting criteria are: fresh water aquatic, human toxicity, climate change, and marine aquatic. The simple additive weighting (SAW) formula is :

$$rij = \begin{cases} \dfrac{Xij}{\text{Max } Xij}, \text{if } f \text{ is benef atribute} \\ \dfrac{\text{Min } Xij}{Xij}, \text{if } j \text{ is costatribute} \end{cases} \tag{2}$$

Where rij is the normalized performance rating of alternatives Ai on attribute Ci; i = 1, 2, 3, ..., m and j = 1, 2, 3, ..., m. Alternative preference value (Vi) is given as: Greater V value, indicating that the alternative Ai is selected.

RESULT AND DISCUSSION

The calculation result of supporting material required by using material flow analysis (MFA) approach for once production process is as follows :

TABLE 1. Total Consumption Summary Of Supporting Material

Total Consumption of Supporting Material	Amount (kg)
Water	47170
Antiseptic	15
NaOH	15
Teepol	277
Lime	345
Na2S	345
Natrium Formiat	165
H_2SO_4	70
HCOOH	14
Mimosa	285
Sandrolic GS	144
Paint	29
Paint Protector	14
Lighter	22

Then, after the result of total supporting materials consumption obtained, the data is entered into openlca software version 1.4.1. In data processing, mimosa impact value calculated. In addition, the other vegetable tanning agents that will be proposed to be an alternative solution also calculated, so the comparisons can be made to determine the value of the impact generated by each vegetable tanning agent. Comparison of the effects of the four vegetable tanning agents can be seen in table 2.

Based on the reference value and unit of each tanning agent that has been obtained, then created a comparison chart of all alternative tanning agent. Comparison of the diagram is shown in figure 1.

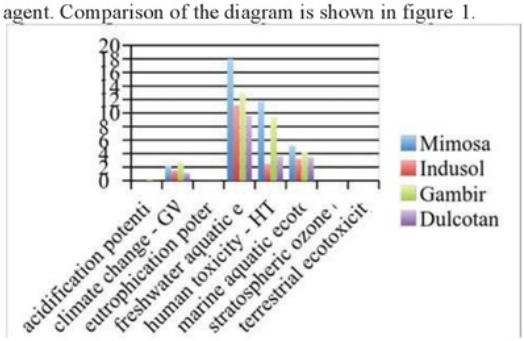

FIGURE 1. Comparison of Impact Assessment of Mimosa, Indusol, Gambier, and Dulcotan.

Based on the results of environmental impact assessment on the use of vegetable tanning agents, can be seen that the impact of the LCA parameter, Indusol is better on fresh water aquatic factor, human toxicity, aquatic and marine than other. While the climate change factor, dulcotan better than other vegetable tanning agents.

TABLE 2. Impact Assessment Comparison Value Of Mimosa, Indusol, Gambier, and Dulcotan

Impact category	*Value*				*Reference unit*
	Mimosa	*Indusol*	*Gambier*	*Dulcotan*	
Acidification potential - average European	0.0193	0.0126	0.2177	0.012	kg SO2-Eq
Climate change - GWP 100a	2.1664	1.5311	2.7454	1.1482	kg CO2-Eq

Eutrophication potential - average European	0.0187	0.012	0.0268	0.0098	kg NOx-Eq
Freshwater aquatic ecotoxicity - FAETP 100a	18.002	11.123	12.974	9.6956	kg 1,4-DCB-Eq
Human toxicity - HTP 100a	11.702	2.4872	9.4462	3.6375	kg 1,4-DCB-Eq
Marine aquatic ecotoxicity - MAETP 100a	5.1550	3.2253	4.2961	3.463	kg 1,4-DCB-Eq
Stratospheric ozone depletion - ODP 40a	3.61 E-10	1.41 E-09	4.17 E-09	2.26E-09	kg CFC-11-Eq
Terrestrial ecotoxicity-TAETP 100a TAETP 100a	7.36 E-10	6.86 E-05	7.24 E-05	2.44E-05	kg 1,4-DCB-Eq

Table 2 present the impact assessment value of mimosa, indusol, gambier, and dulcotan. The reference unit of several was based on international standard. The value show that climate change, freshwater aquatic, and human toxicity has higher value than other impact category. It is mean that these three items need to be the focus to be reduced and potential to be a problem. After the impact value is obtained, then start the decision-making process by using fuzzy multi-attribute decision making (FMADM) approach. Weighting obtained from the questionnaire. Then, do the normalization process by using the equation 2. Calculate the value of the vector by multiplying the result of the normalization with weighting values, as shown in table 3.

TABLE 3. Vector Calculation Value

Weighting (W)		0.75	0.75	0.5	0.5
Vector	**Mimosa**	0.25	0.5	0.5	0.25
	Indusol	0.375	0.75	0.5	0.5
	Gambier	0.375	0.75	0.5	0.5
	Dulcotan	0.75	0.75	0.5	0.5

From the results of table 3, can be found alternative ranking that will be chosen by adding the value of the vector of each alternative. The results shown in table 4.

TABLE 4. Result Of Ranking

Alternative	Value	Rank
Mimosa	1.5	4
Indusol	2.125	2
Gambier	2.125	3
Dulcotam	2.5	1

Based on the results of table 4, the best alternative to be a vegetable tanning agent in the production process by considering fresh water aquatic, human toxicity, climate change, and marine ecotoxi12city quatic is Dulcotan.

TABLE 5. Sensitivity Analysis

Alternative		Mimosa	Indusol	Gambier	Dulcotan
Existing		1.5	2.1250	2.1250	2.5000
Vector Value	+5%	1.4875	2.2313	1.8375	2.6250
	-5%	1.3458	2.0188	1.6625	2.3750

Vector Value	+10%	1.5583	2.3375	1.9250	2.7500
	-10%	1.2750	1.9125	1.5750	2.2500
Vector Value	+20%	1.7000	2.5500	2.1000	3.0000
	-20%	1.2750	1.9125	1.5750	2.2500
Vector Value	+30%	1.8417	2.7625	2.2750	3.2500
	-30%	0.9917	1.4875	1.2250	1.7500

Then performed a sensitivity analysis. Sensitivity analysis here is based on the results of data processing and calculation. Sensitivity analysis result shown in table 5. Sensitivity analysis was conducted to determine the extent of weight change in the selection of the alternative solution effect due to changes of the relative importance given by the decision maker. In the present study, sensitivity test begins with the addition and subtraction sum of 5% to 30% to weighting value to find out if there is a change to the selection of the best alternative solutions. The results of the sensitivity analysis is no change of the best alternative solutions rank.

CONCLUSION

From the results of this research, noted that the environmental impact generated by using mimosa as vegetable tanning has a high impact on fresh water aquatic which is 18.00216429 kg PO4-Eq, human toxicity is 11.70178588 kg of 1,4-DCB-Eq, marine aquatic toxicity is 5.155013731 kg of 1,4-DCB-Eq, and climate change is 2.166417028 kg CO2-Eq. To reduce the environment impact, some of alternative solution proposed to replace the vegetable tanning agents, which are indusol, gambier, and dulcotan. By considering the impact to environment and human, then the selected alternative solution is dulcotan. Dulcotan has the lowest impact to environment. This study shows that the selection of vegetable tanning agent becomes a determining factor to the amount of impact on the environment and humans. For further research, the price factor must be considered in decision making. The availability factor also be considered because some tanning agents are difficult to be obtained, even to be imported, so the industry need to expense the shipping cost.

ACKNOWLEDGMENT

The authors greatly appreciate the financial support of Yayasan Amanah Pelalawan (YAP).

REFERENCES

1. M. Aloy, A. Folachier, B. Vulliermet,. "Tannery & pollution". Centre Technique Du Cuir, Lyon, France, 1976.
2. K. Atassanov, "Intuitionistic fuzzy sets, theory and applications," Physica-Verlag, Heidelberg, 1999.
3. H. Bustice, F. Herrera, J. Montero, "Fuzzy sets and their extensions: representation, aggregation and models," Physica-Verlag, Heidelberg, 2007.
4. 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 Precedia Vol. 61 pp. 1063-1066 2014.
5. M. Chowdury, M. G. Mostafa, T. K. Biswas, A. K. Saha, "Treatment of leather industrial effluents by filtration and coagulation processes. Water Resources and industry Vol. 3 pp11-22, 2013.
6. 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
7. G. H. Insel, E. Görgün, N. Artan, D. Orhon, "Model based optimization of nitrogen removal in a full scale activated sludge plant," Environment Engineering Science Vol. 26 pp 471–80, 2009.
8. G. J. Klir, "Uncertainty and information: foundations of generalized information theory," Wiley-Interscience, Hoboken, NJ, 2006
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. A. Mannucci, G. Munz, G. Mori, C. Lubello, "Anaerobic treatment of vegetable tannery wastewaters: a Review. Desalination, 264, pp 1-8, 2010.
11. E. Purnomo, "Pengetahuan dasar teknologi penyamakan kulit," Akademi Teknologi Kulit. Yogyakarta, 1985.
12. UNIDO, "Future trends in the world leather and leather products industry and trade," United Nations Industrial Development Organization, Vienna, 2010.

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