CHEMICAL ENGINEERING TRANSACTIONS
VOL. 52, 2016
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Petar Sabev Varbanov, Peng-Yen Liew, Jun-Yow Yong, Jiří Jaromír Klemeš, Hon Loong Lam

ISBN 978-88-95608-42-6; **ISSN** 2283-9216
DOI: 10.3303/CET1652197

Environmental Index for Palm Oil Mill

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Palm oil mill has been regarded as a profit making industry for the past decades. Besides revenue from the palm oil production itself, the abundance of biomass could generate high economic return to the palm oils mill by converting it to value added products. However, the palm oil industry currently suffered various criticisms and negative reports from the international non-government organizations on the environmental issue. This paper presents the development and the applicability of environmental index (EI) for palm oil mill in order to enhance the competitiveness of the industry. The methodology will include the index development and identify area of weaknesses (hotspot). The index will be able to identify performance of the mills in Environmental aspect against benchmarks and differentiate every mills performance. By this, the mills can easily identify its hotspot and take necessary steps to improve. The system will also benefit the marketing team to market its products (CPO, PKO etc.) to niche markets that seek uptake from mills with lowest footprints (Carbon, water, energy etc.). The results can be used not only to evaluate the performance of an operating process against standard benchmarking but also to establish the best environmental practices among palm oil industry. It is anticipated that the development of environmental index will be an important instrument for supporting sustainable operation for palm oil mill.

1. Introduction

Some of the research done regarding environmental issues on palm oil area are waste utilization through thermochemical conversion liquefaction (Awalludin et al., 2015) and innovation on effective utilization of waste to become renewable energy (Yusoff, 2006). Other than that, eco-labelling for carbon footprint modelling which can help to measure the value taken of product and services thus reducing impact to the environment (Choong and Alison, 2013). Most of sustainability trend research from 2004 to 2013 in Malaysia dominate to technology and residue use area which include to the palm oil mill effluent (POME) treatment and value added product from the POME. The other hand, index related research is the ENERGY STAR® energy performance indicator. The ENERGY STAR industry program focuses on encouraging and enabling sustainable corporate energy management (Gale et al., 2008). Meanwhile, Environmental performance index (EPI), is a global metric of environmental performance between the countries to protect ecosystems and human health from environmental harm (NRE, 2014). Tan et al. (2015) proposed a development of the Low Carbon Indicator (LCCI) for the research that focused on evaluation, implementation and standardization of low carbon cities (LCC) by measure on waste management, environment control, economic factor and municipal solid waste (MSW) of the country. Thus, it can be said that Malaysia is still lack of research in palm oil mill area as most of the research only focused on palm oil plantation area. On top of that tool or application that can measure the palm oil mill environmental index is needed. The results can be used not only to evaluate the performance of an operating process against standard benchmarking but also to establish the best environmental performance among palm oil industry.

Please cite this article as: Jamaludin N.F., Ab Muis Z., Hashim H., Ahamad R., 2016, Environmental index for palm oil mill, Chemical Engineering Transactions, 52, 1177-1182 DOI:10.3303/CET1652197

2. Methodology

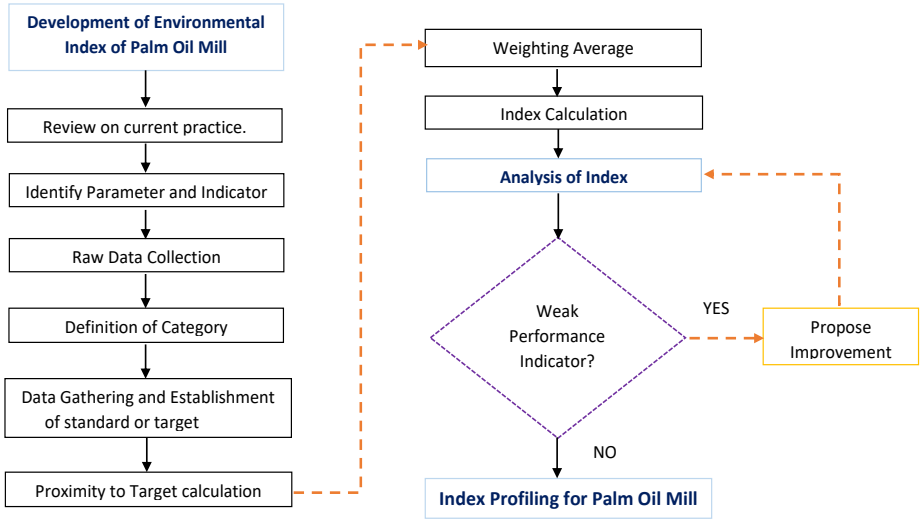

Figure 1: Overall methodology of Environmental Index for Palm Oil Mill

First, extensive review on previous work is conducted to review the drawback of the existing index system. Secondly, from the availability of the data and literature reading, the potential factors and indicators are identified. Then, the indicator will be classified according their group called as parameter. This parameter will represent the indicator grouping for each environmental aspect. Once the indicator, parameter and aspect have been identified, standard data collection step are started through palm oil related agencies such as FELDA, RSPO and MSPO and from the industrial study. The data collected are varies in term of unit and scale, to make it dimensionless, data normalization method is needed to ensure the consistency and accuracy of the data. The SI are analysed using radar chart so area of weaknesses (hotspot) are clearly identified. The methodology flowchart of environmental index for palm oil mill as shown in Figure 1.

2.1 Review and raw data collection on current practice in palm oil industry

First step, comprehensive review on palm oil mill and management will be conducted to understand the current practices in palm oil industry. The raw data will be gathered from selected palm oil mill or previous studies to develop framework of the index. Besides, source of data could be palm oil mill manual, discussion with plant manager or staff and data extraction from palm oil mill current data system. Palm oil mill will be classified with different category such as big scale mill, small scale mill, and their technology.

2.2 Indicators and parameter selection

In depth, parameter is a benchmarks of the category and obtained from previous study, palm oil policies and literature. Therefore, parameters obtained are assigned to one of the suitable category, water or air. Indicator is a tool to measure the parameter and monitor the sustainability level. Generally, indicators are selected based on the relevance, performance orientation, transparency, data quality, data sustainability and data custodian (NRE, 2014). Table 1 profiled the indicators and parameters available. Indicators are given a symbol and mapped into the palm oil process flowchart as in Figure 2 to give a clear visual of where the indicator located.

Table 1: List of Parameter and Indicator

	Category	Parameter	Symbol	Indicator	Symbol
	Water	Water Consumption	E1	Use of Water	UOW
		Water Quality	E2	BOD5	BOD
				COD	COD
Environmental Index for Palm Oil Mill				Oil and Grease	O&G
				Suspended Solid	SS
				pH	PH
	Air	Air Quality	E3	NO_X	NO_X
				CO_2	CO_2

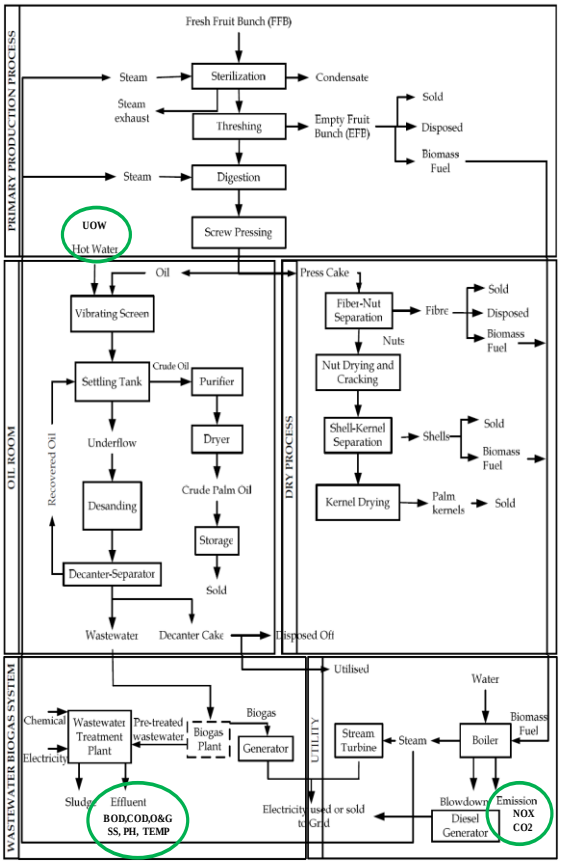

Figure 2: Indicator Location

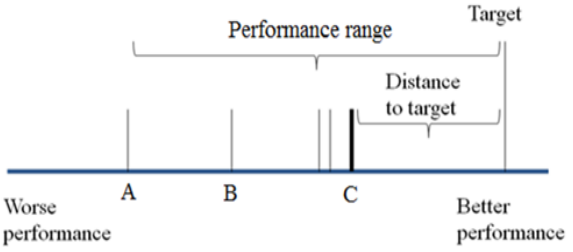

Figure 3: Proximity to Target Concept

$$\frac{raw\ data - min}{target - min} \times 100 \quad (1)$$

$$\frac{\max - raw\ data}{\max - target} \times 100 \quad (2)$$

2.3 Data gathering and establishment of standard or target value

Standard value will be obtained from related authorities such as FELDA, DOE and etc. Besides, certain value will use the industries target as a standard value. For instant, FELDA target to increase Oil Extraction Rate (OER) production annually more than 21.94 %. Thus, 21.94 % can be used as a benchmark to be achieved by the indicator. By having the standard value, it can be determined the performance of each indicator as opposed to the target or specify standard. However, in case of the indicator does not have any target or standard, trend line data from the industry will be used to determine the best condition to be set as our target.

2.4 Proximity to Target (PTT)

The indicator collected are different in unit and dimension. Each indicator either positive (type A) or negative indicator (type B), where the positive indicates the high value equates good performance and vice versa (Sieting, 2015) the concept of Proximity to Target (PTT) is illustrated in Figure 3. PTT is a simple approach of measure on how close each mill indicator compared to the palm oil standard. Thus, indicators are normalized using Eq(1) for type A indicator and Eq(2) for type B indicator to get their PTT score.

2.5 Weightage Average

In this step, it required expert view to give weight to the parameter using questionnaire and interview because not every parameter have same value of importance. Might be this parameter will be more important than another parameter so we will take expert view and opinion to give rating to the parameter.

2.6 Index Calculation

Figure 4 shows calculation flow steps to obtain the index value. It starts from normalize data using PTT, averaged it according their parameter, sum up to the aspect score and lastly obtain the index.

2.7 Sustainability Index Profiling and Analysis of Index

Environmental Index Profiling is a method to collect and clustered the result according to their own mill. Therefore, easier to compile and make comparison between the mill. The analysis of Sustainability Index is presented using radar chart. Radar chart are selected because it gives explicit results analysis by clearly shows areas for improvements. The outer ring of the web which mean 100 % score, so towards the outer ring it shows a better result. Radar chart allows the industries to quickly recognize area which they perform well or to identify area for improvement.

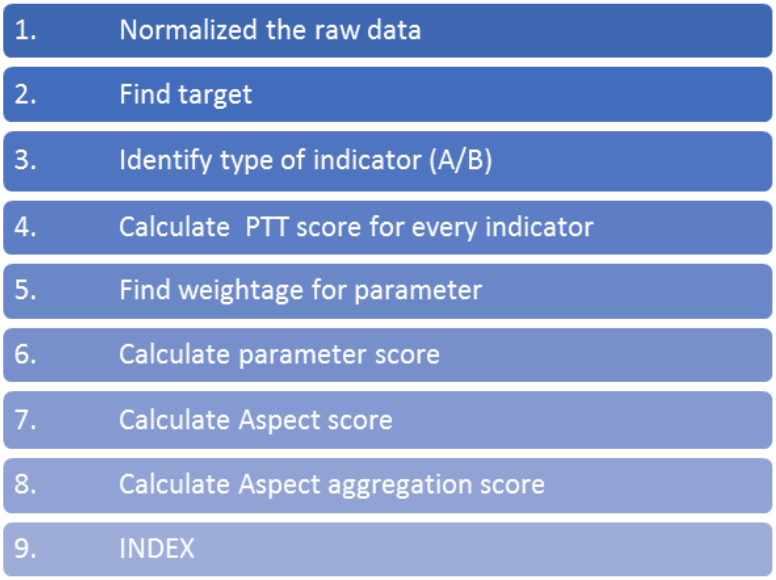

Figure 4: Index Performance Calculation Step

3. Preliminary Result

Analysis results and interpretation of the Environmental Index of Palm Oil Mill. It can be e analyses in various way, such as index profiling, bar and radar chart. Up to this part 8 indicators were identified and classified into 3 parameters that will be grouped into environment category.

3.1 Database

Database include category, parameter, list of indicator, parameter limit of indicator, type of indicator and raw data of each indicator as shown in Table 2.

Table 2: Palm Oil Mill Environment Database

Category	Parameter	Indicator (from literature)	Unit	Parameter Limit (Standard)	Type	Mill (Raw Data)				
						A	B	C	D	E
Water	Water Consumption	Use of water	t	1.3	B	3.42	2.95	3.67	4.01	3.51
	Waste Water Quality after treatment	BOD_5	mg/L	100	B	25,000	25,000	22,700	25,000	25,545
		COD	mg/L	1,000	B	50,000	50,000	44,300	70,900	55,775
		Oil and Grease	mg/L	50	B	8,000	4,000	4,000	4,850	8,020
		Suspended Solid	mg/L	400	B	19,000	18,000	19,780	25,800	18,479
		pH	-	7	B	4.5	4.7	4.05	4.52	3.4
Air	Air Quality	NO_X	kg	-	B	0.04	0.08	0.12	0.1	0.2
		CO_2	kg	-	B	13.74	43.47	60.7	161.2	142.2

3.2 PTT Score result

From the raw data, PTT score will be calculated using Eqs. (1) and (2) depends on type of indicator in percentage form as in Table 3.

Table 3: Indicators PTT Score

Category	Parameter	Indicator (from literature)	Unit	Parameter Limit (Standard)	PTT Score (%)				
					A	B	C	D	E
Water	Water Consumption	Use of water	t	1.3	21.8	39.1	12.6	0	18.5
	Waste Water Quality after treatment	BOD_5	mg/L	100	57.2	2.14	11.2	6.51	0
		COD	mg/L	1,000	29.9	29.9	38.1	0	21.6
		Oil and grease	mg/L	50	0.25	50.4	63	39.8	0
		Suspended Solid	mg/L	400	26.8	30.7	23.7	0	28.8
		pH	-	7	30.6	36.1	18.1	31.1	0
		Temperature	˚c	45	11.6	9.3	0	6.98	41.9
Air	Boiler Emission (Air Quality)	NO_X	kg		100	75	50	62.5	0
		CO_2	kg		100	79.8	68.2	0	12.9

3.3 Weightage

Table 4 shows list of parameter with their own weightage.

Table 4: Parameter Weightage

Category	Parameter	Symbol	Weightage (%)	Indicator	Symbol
Water	Water Consumption	E1	30	Use of Water	UOW
	Water Quality	E2	40	BOD_5	BOD
				COD	COD
				Oil and Grease	O&G
				Suspended Solid	SS
				pH	PH
				Temperature	TEMP
Air	Air Quality	E3	30	NO_X	NOX
				CO_2	CO2

3.4 Parameter Score

Average of PTT score will get parameter score and using weightage in Table 4, parameter score will be calculated to parameter aggregation score.as in Table 5

Table 5: Parameter Score and Parameter Aggregation Score

	Parameter Score			Parameter Aggregation Score		
Category	Water		Air	Water		Air
Parameter	E1	E2	E3	E1	E2	E3
Weightage	30	40	30			
A	21.77	26.04	100.00	6.53	10.42	30.00
B	39.11	26.43	77.42	11.74	10.57	23.22
C	12.55	25.66	59.08	3.76	10.26	17.72
D	0.00	14.06	31.25	0.00	5.62	9.38
E	18.45	15.39	6.45	5.54	6.16	1.94

3.5 Category and Index Score

The summation of parameter aggregation will get category score and lastly the summation of category score will get Environmental Index Score for each mill as in Table 6.

Table 6: Category and Environmental Index Score

Mill	Category Score		Environmental Index Score
	Water	Air	
A	16.95	30.00	46.95
B	22.31	23.22	45.53
C	14.02	17.72	31.74
D	5.62	9.38	15
E	11.7	1.94	13.64

3.6 Environmental Index Analysis

Based on the score the index will be analyse using Bar chart and Radar chart. Bar Chart will show environment index performance of every mill. Industry can compare their performance against other mill industry, thus they aware their performance rating compared to others. If identified their mill have the low rating the industry can zoom in the problem factor using Radar chart. Both method will help industries identify their weaknesses and area of improvement effectively. As an example, in Figure 3 Mill D shows low performance, and one of the hotspot is ineffective usage of water as shown in Figure 4.

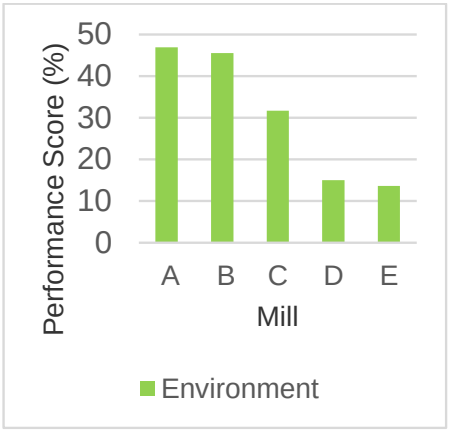

Figure 3: Environmental Index of every Mill

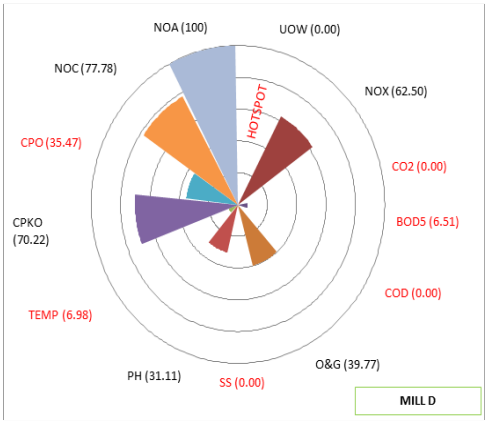

Figure 4: Indicator analysis of Mill D (Radar chart)

4. Conclusions

A new systematic approach to analyse palm oil mill environment index performance has been developed. Using the database and index calculation, this system is able to determine the EI performance rating between palm oil mill industries. Besides, it can give information to the industry the area of weaknesses (hotspot) that should give an attention.

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