LIFE CYCLE ASSESSMENT AND ECO-EFFICIENCY: CASE IN LATEX CONCENTRATE PROCESSING

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ABSTRACT

Demand to natural rubber increased in the last 5 years, this is shown by level of high relative price for rubber market, and still go on up to year 2025. This condition will have potential impact to the environment starting from cultivation process up to the generation industry. Some chemicals must be added to maintain the grade of latex concentrate from natural rubber, energy using and water using which all these will give impact to environment. The impact such as decreased the quality of water body, air emission. Life cycle assessment is a decision making tool to identify environmental burdens and evaluate the environmental consequences of a product, process or service over its life cycle. Eco-efficiency is the path of business and industry can take towards the goal of ecologically sustainable development and links environmental and financial performance. Accounting must be done to know environmental burdens of the activities, and will give an information how eco-efficiency the activities are. The result will show the effect of using chemical and energy in eco-efficiency.

Keywords: life cycle assessment, eco-efficiency, natural rubber, latex concentrate

INTRODUCTION

Requirement of natural rubber progressively rising with the increasing of human life standard. In 2005 natural rubber production of the world reach 8.5 million ton, with growth of Indonesia production 3% in a year. According To IRSG, in study Rubber Eco-Project (2005), estimate there will be lacking of natural rubber in two decade forwards, it means that up to 2025 rubber price remain stable at about US$ 2.00/kg.

The latex of *Hevea brasiliensis* consists of rubber and non-rubber particles dispersed in an aqueous serum phase. Apart from the rubber hydrocarbon which is the principal non aqueous component, a large number of non rubber constituents are also present in relatively small amounts.

It is well known that the commercial high-ammonia (HA) natural rubber (NR) latex concentrate can be produced by centrifugation of field NR latex tapped from the rubber tree. By applying this process, most of the non-rubbers solids, about two thirds of the water-soluble non-rubbers and small NR particles or skim rubber are removed. While the surface-active species or indigenous surfactants (derived from protein–lipid) remain in the serum and/or on the rubber particles in the concentrate fraction. However, the skim rubber has always been discarded and has not received much attention due to the high ratio of aqueous phase in the latex. Previous study reported that the skim latex contained about 7% total solid content (TSC) and 5% dry rubber content (DRC).

Concept of eco-efficiency was developed by the WBCSD (World Business Council for Sustainable Development) in 1992 and widely recognized by the business world (Verfaillie, 2000).

WBCSD defines eco-efficiency as follows: “Eco-efficiency is achieved by the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth’s estimated carrying capacity.

Firms which used eco-efficient strategies and, as consequence, achieve reduced costs and increased profits should be more highly valued by the market than similar firms that do not adopt eco-efficient business strategies (Sinkin, 2008). Eco-efficiency can be done by process improvements and technological innovation.

Life cycle assessment (LCA) is a decision making tool to identify environmental burdens and evaluate the environmental consequences of a product, process or service over its life cycle from cradle to grave by identifying quantitatively or qualitatively the energy and materials used, and wastes released to the environment, and to assess the impacts of those energy and material uses and releases to the environment. The assessment includes the entire life cycle of the product or activity, encompassing extracting and processing raw materials; manufacturing; distribution; use, re-use, maintenance; recycling and final disposal; and all transportations involved.

LCA has been standardized by the International Organization for Standardization (ISO 14040 and 14044) and forms the conceptual basis for a number of management approaches that consider a product across its life cycle, covering resource acquisition, product manufacturing, use and end of life.

Description of the Latex Concentrate Producing in Factory A and B

Factory A

Latex from LTT (Latex Transport Tank) pumped into acceptance tank (OT= Onvangen Tank). Into Onvangen Tank enhanced Diammonium Phospate (DAP) which aim to improve the Mechanical Stability Time (MST) by eliminate Mg into Mg^{++} in latex. Mg^{++} can influence latex stability.

From centrifuge latex concentrate is poured into Weight Tank. From Weight Tank latex concentrate is poured into Mixing Tank (MT). In MT is done addition of NH_3, preservative as lauric ammonium. Latex concentrate has standard quality in NH_3, DRC, VFA, TSC and will keep in Storage Tank in a few days before sent.

Factory B

Latex is being flowed from Transport Tank into Recieving Tank which lauric acid is added and DAP (*Diammonium Phospat*) . After precipitation for 2 hours latex is flowed into separator. In separator latex will concentrate by separate impurities and non rubber material. Latex concentrate will then flow into blending tank by adding lauric acid 10%, concentrated latex and ammonia. Store in blow case before to get the specification before send tostorage tank.

METHODOLOGY

The objective of the study is to assess eco-efficiency of two factories A and B that produce latex concentrate from natural rubber and comparing eco-efficiency of the factories by using life cycle assessment methodology.The study is to process natural rubber 10,000 tones into latex concentrate by centrifuging.
Boundary of the process is production latex concentrate from natural rubber and environment influence as a function of eco-efficiency will be obtained from: chemical consumes, water and electricity (energy) and will appear by calculating impact categories and damage assessment by using Eco-Indicator 99.

Impact assessment

Impact assessment is a technical, quantitative and/ or qualitative process to characterize and assess the effects of the environmental burdens identified in the inventory. Impact assessment was performed with the Eco indicator 99 methodology to make an environmental assessment of a product by calculating indicator scores for material and processes used.
Three conditions affecting human and environment are considered: Human Health, Ecosystem Quality and sufficient supply of Resources. Damage to Human Health are expressed in Disability Adjusted Life Years (DALY), and develop for respiratory and carcinogen effects, the effect of climate change, ozone layer depletion and ionizing radiation. Damages to Ecosystem Quality are expressed as Potentially Disappeared Fractions (PDF), of species disappeared in a certain area, due to an environmental load. The PDF values are then multiplied by the area size and the time period to obtain the damage. Damage category Ecosystem Quality consists of ecotoxicity, acidification and eutrophication, land use and land transformation. Ecotoxicity is expressed as the percentage of all species present in the environment living under toxic stress (Potentially Affected Fraction or PAF). As this is not observable damage, a rather crude conversion factor is used to translate toxic stress into real observable damage, i.e. convert PAF into PDF. Damages to Resources are expressed as the surplus energy for the future mining of the resources (as minerals and fossil fuel).

Measuring Eco-Efficiency

Eco-efficiency = Product or Service value/Environmental influence (added).
Product or service value in this experiment is showed as flow rate of the process.
Environmental influence here the same as components in impact assessment: damage assessment and impact categories.

RESULT AND DISCUSSION

Damage assessment as a function eco-efficiency

Figure 1 showing that in latex concentrate processing, *resources* is the biggest impact component of the damage followed by *ecosystem quality* and *human health*. Usage of electrics give the largest contribution that cause resource damage. Factory B contribute more damage than factory A, in each parameter of damage. After normalization factory B contribute damage more than factory A especially in resources and human health fig.2. Normalization will show relative contribution of the calculated damages to the total damage caused by a reference system. Usually the reference system is the sum of all emissions and all resource extractions in the world or in a given part of the world, during a certain time. Damage assessment as environment influence give a high value of eco-efficiency factory A in every parameter especially as human health. By normalization, the parameter of damage assessment as a function of eco-efficiency could be compared each other and ecosystem quality as environment influence give the highest value of eco-efficiency, followed by human health and resources (fig.4). Factory A more eco-efficient than factory B and probably electricity cause the lowest eco-efficiency compared to chemical and water, this can be shown later in impact categories.

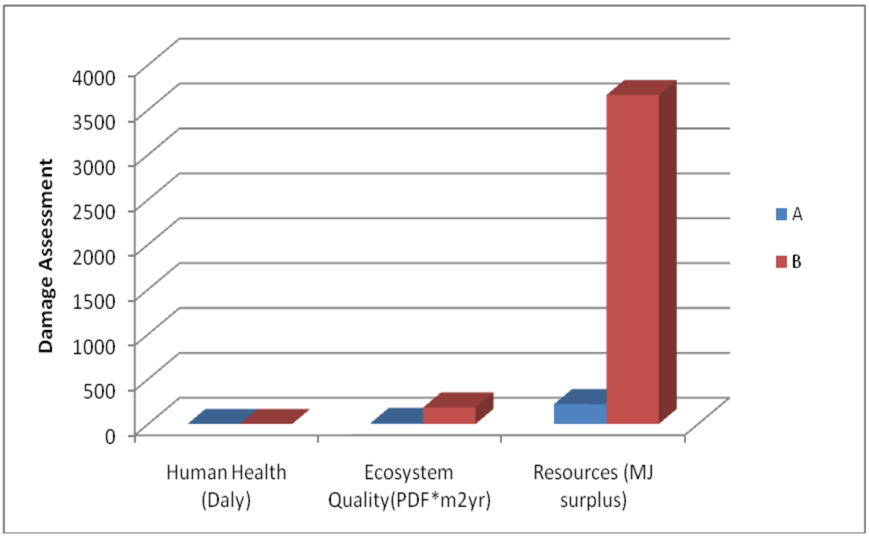

Figure 1: Comparison damage assessment between factory A and B

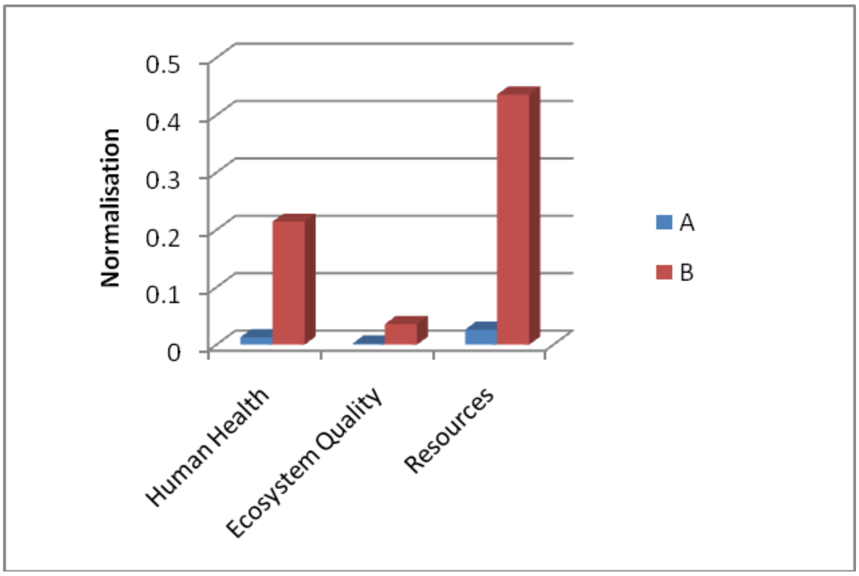

Figure 2: Comparison normalisation damage assessment between factory A and B

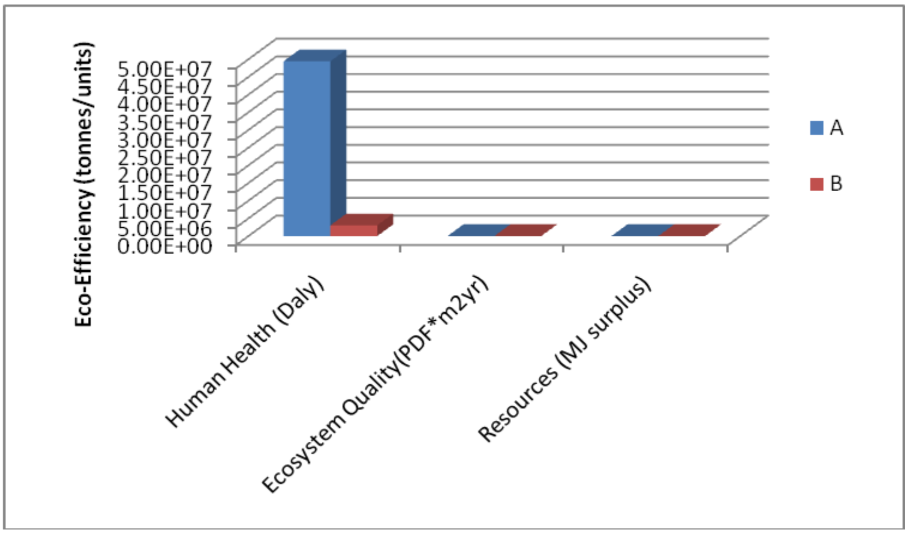

Figure 3: Comparison Eco-Efficiency as function of damage assessment

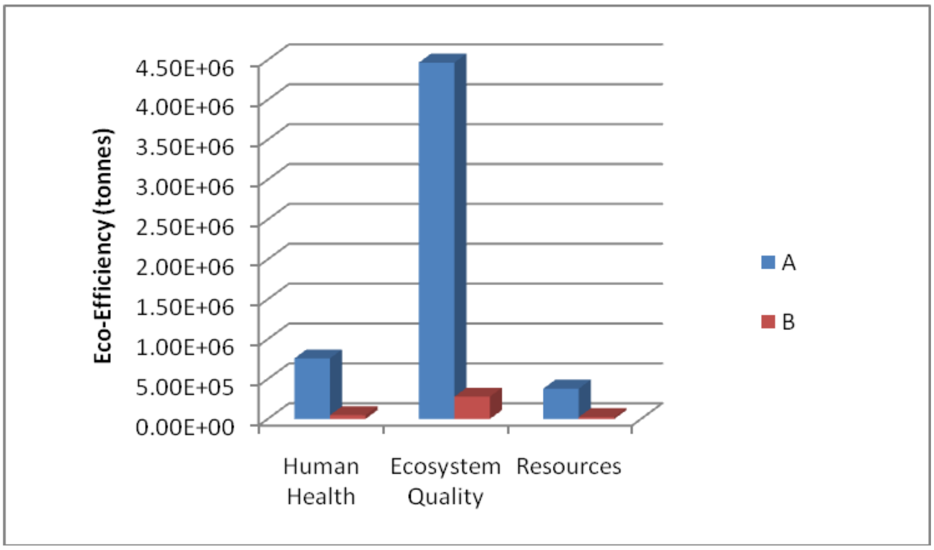

Figure 4: Comparison Eco-Efficiency as a function of damage assessment after normalisation

Impact categories as a function eco-efficiency

In characterization shows that respiratory in-organics in human health has a high impact compare to other parameter, ecotoxicity in ecosystem quality and fossil fuels in resources (fig. 5)

After normalization, fossil fuel has the highest impact from all categories followed respiratory in-organics, this mean that impact of using electricity dominant than chemical or water (fig. 6) Factory B contribute more burdens to environment than factory A, and will make a high environment influence in eco-efficiency. Figure 7 and 8 shows impact categories as a function of eco-efficiency, before and after normalization and eco-efficiency factory A higher than factory B for all categories.

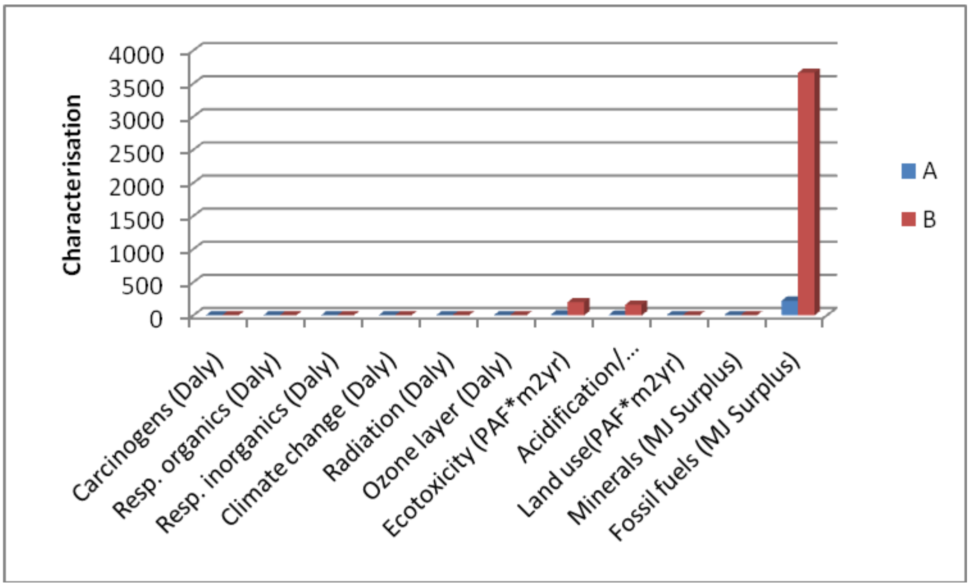

Figure 5: Comparison impact categories beetwen factory A and B

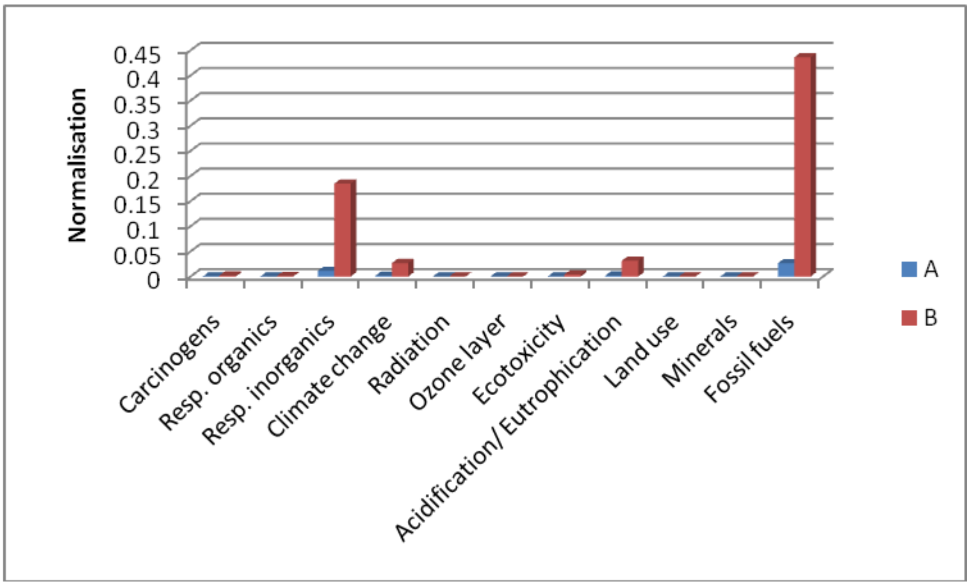

Figure 6: Comparison normalisation per-impact category

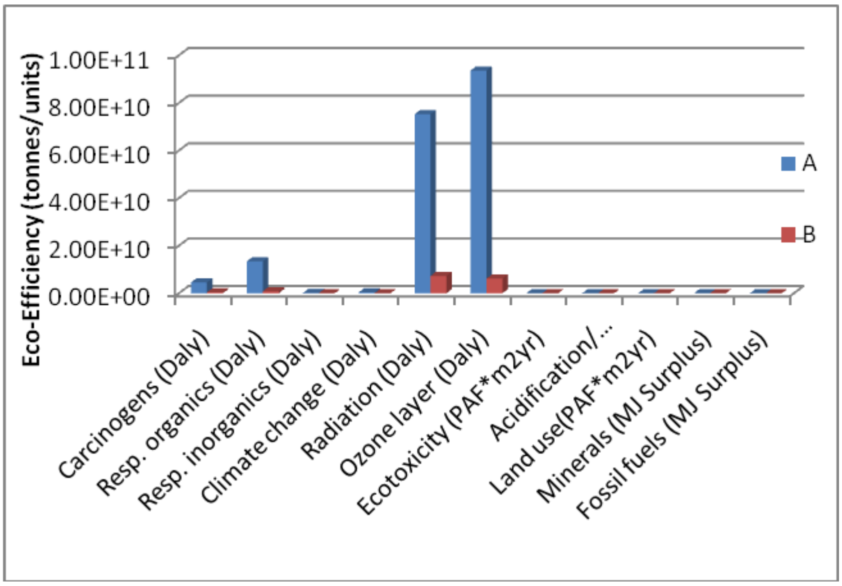

Figure 7: Comparison Eco-Efficiency as a function of impact categories

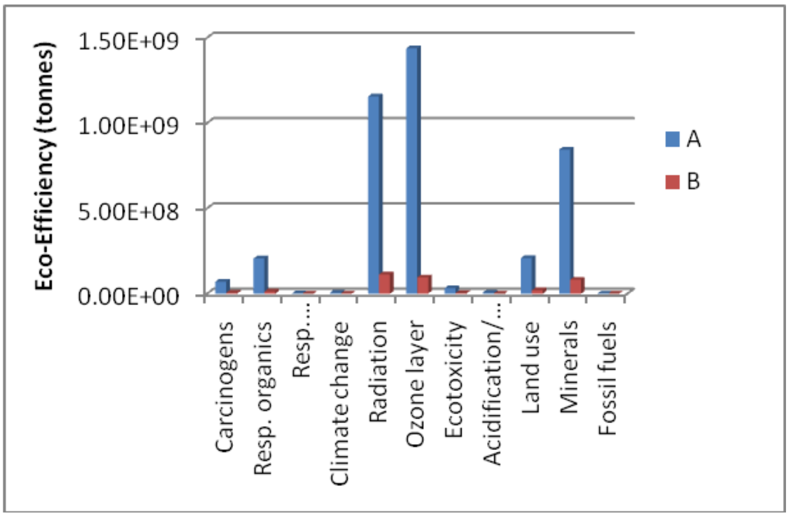

Figure 8: Comparison Eco-Efficiency as a function of impact categories after normalisation

CONCLUSION

From study Eco-Efficiency in latex concentrate processing, we can draw the following conclusion:

Factory A more eco-efficient than factory B, fossil fuels as the component of resources become the influence of environment that cause less eco-efficiency followed respiratory in-organic as component of human health. Process will *influence burdens to environment, so it is needed to change the process by using less chemical, water and electricity, such as membrane processing.*

ACKNOWLEDGEMENTS

The authors are thankful to PT. Perkebunan Nusantara 3, Medan, Sumatera Utara, Indonesia and Institute of Research Management and Consultancy (IPPP) University of Malaya for their support in this research.

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