IMPLEMENTATION OF LIFE CYCLE ASSESSMENT ON FISH PRODUCTS

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ABSTRACT

Life Cycle Assessment (LCA) is a technique to assess the environmental aspects and potential impacts associated with a product or service, by: compiling an inventory of relevant inputs and outputs of a product system, evaluating the potential impacts associated with those inputs and outputs, interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.

The LCA studies the environmental aspects and potential impacts throughout a product's life from raw material acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health and ecological consequences.

This research was intended to find the LCA of sea fishes, which were caught and sold in Baron, Drini and Ngrenehan coasts in Gunung Kidul region of Jogjakarta Special Province. This region is the most potential place in Jogjakarta in producing sea fishes. Other aims of this research were to know the potency of sea fishes in three coasts and to evaluate the environmental impacts if the fishes were processed into the foods. The samples of the research were fresh fishes, fried fishes and barbequed fishes.

The results of the research depicted, that for catching 1 kg fresh fish was needed 3600 kcal human energy; 7.47 MJ for fuel and produced CO_2 0.385 mg, SO_2 0.116 mg, NO_x 0.0743 mg and particle's pollutant 0.0107 mg. If the fresh fishes were processed into the barbequed or fried fishes, the processing of 1 kg fresh fish was needed 62.5 kcal human energy, 3.50 MJ for fuel and yielded the gas of CO_2 38.10 mg, SO_2 0.0825 mg, NO_x 0.585 mg and particle's pollutant 0.7325 mg.

The potency of the beach was average 100-150 kg/boat/day. To know the food safety of the fishes, the microbiological tests were conducted. The results of these tests were; Total Plate Count lied between 10^5 and 10^8, all the samples were negative from the presence of *Escherichia coli*, *Salmonella* sp and *Staphylococcus* sp.

INTRODUCTION

At present Indonesia is faced the preparation of the world global trade. In this global trade foreign producers can sell their products in Indonesia freely, if they are fulfilling the global requirements for example quality standards. Some quality standards, which are already known, are ISO 9000 series, ISO 14000 series, HACCP (Hazards Analysis and Critical Control Points) Certificate and some other certificate due to the religious needs.

ISO 14000 series are designed as an environmental management system in the industries, which produce the goods or services for the consumers. It means, on one hand the producers have to maintain the environment and to use the natural resources optimally during they produce their own products. On the other hand, the waste of the processing in the industry must be controlled and minimized, so the sustainability of the environment can be managed.

Since 1997 some country members of European Union have already applied the ISO 14040: Environmental Management – Life Cycle Assessment. They have tried to implement

this system for all of their products. The all consumed goods have already been counted the effects on the environment for producing these products.

Life Cycle Assessment (LCA) is a technique for assessing the environmental aspects and potential impacts associated with a product, by:

- compiling an inventory of relevant inputs and outputs of a product system
- evaluating the potential environmental impacts associated with those inputs and outputs
- interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.

The LCA can be utilized as information source, planning and political tools. Beside of them the LCA can be used as: a. comparing among some products for the same goal, b. optimising the single product life cycle, c. choosing proper parameter for product policies. The implementation of the LCA can be restricted in the industrial environment, regional, national or international (Schlich, 2000)

Gunung Kidul Region is one of five regions in Jogjakarta Special Province, which has high potency in sea products such as fishes, lobsters, sea grass, etc. In this regions there are approximately five Fish Auction Places, where the fishermen and the buyers can make a trade every day after fishing in the sea. Result of Gunung Kidul's sea fishes in 1998 was 726.0 tons and 798.0 tons in 1999. But the fish consumption was only 3.70 kg/capita/years.

This research was intended to find the LCA of sea fishes, which were caught and sold in Baron, Drini and Ngrenehan coasts in Gunung Kidul region. This region is the most potential place in Jogjakarta in producing sea fishes. Other aims of this research were to know the potency of sea fishes in three coasts and to evaluate the environmental impacts if the fishes were processed into the foods.

METHODOLOGY

The samples were taken from fresh sea fishes, which were caught by the fishermen, fried fishes and barbequed fishes. All samples were collected from three coasts, Baron, Ngrenehan and Drini. The samples were transported to Jogjakarta, where some fishes normally were sold. The carrying box was designed to maintain the fishes still in fresh condition by addition of ice. The temperature was measured by thermometer and stopwatch was used to measure the processing time and every steps in the processing.

The research was conducted as follow:

a. Taking the samples (fresh fish, fried fish, barbequed fish) from the fishermen or Fish Auction Place in the three coasts.
b. Observing the fishermen daily activity, from material handling, production, distribution process and marketing in the location. The depth interview with questionnaire was conducted for some fishermen and seafood producers.
c. Observing distribution and marketing patterns, if the fishes were sold in other regions.
d. Microbiological tests for the samples to find out some pathogenic microorganisms, *Escherischia coli, Salmonella* sp and *Staphylococcus* sp, and Total Plate Count.
e. Data analysis to determine the LCA of the samples. Reference for determining the LCA was BUWAL250, which was adopted from Ecocycle (1999), for example burning of 1 kg gasoline produced energy 72.5 MJ, CO2 0.0255 mg/kg, SO2 0.0661 mg/kg and NOx 0.0423 mg/kg.

RESULTS AND DISCUSSION

In this research the five steps to determine the LCA of the products were implemented in Baron, Drini and Ngrenehan coasts. The distribution of the fishes was monitored based on the retailers, who came to the coasts and sold the fishes in the regions near the coasts and in some cities. The fish products as samples were the fishes, which were caught at the time the research

was conducted and ignored the types. The system for determining the LCA in this research was bordered as shown in figure 1.

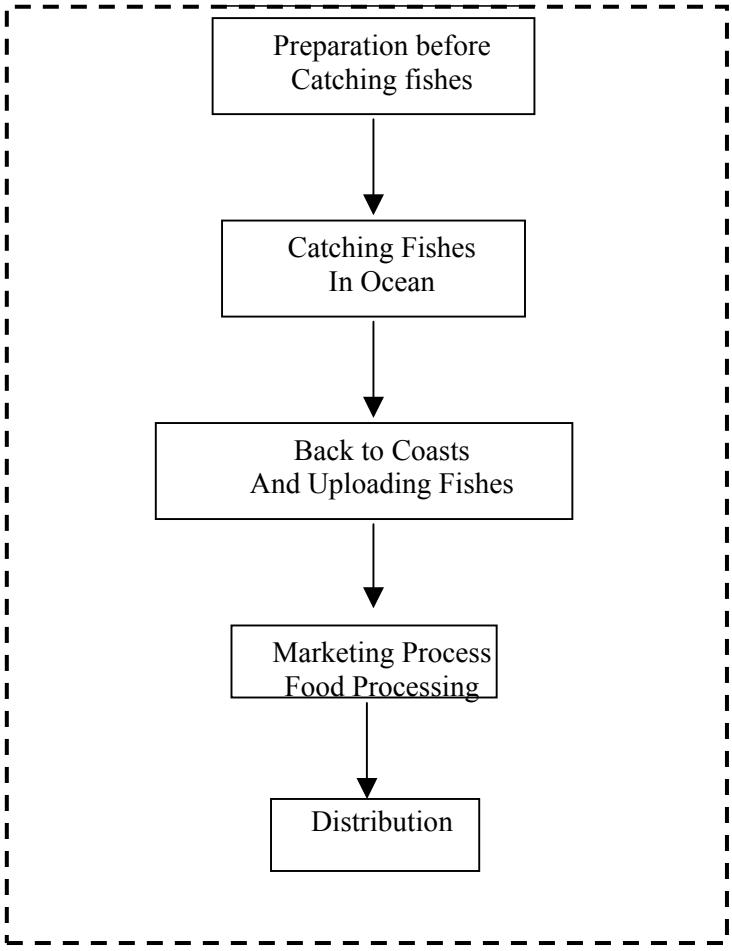

Figure 1. System Boundary for Life Cycle Assessment

The observations were focussed on the activities of the fishermen, namely: the preparation before they went to the ocean, uploading the yield, transaction between the fishermen and the retailers, weighing process in the Fish Auction Place, marketing process and the processing to cook the fishes (frying and barbeque). The overall conditions of the location were depicted in table 1.

Table 1. Condition of research's objects (fishermen and boats)

Coast	Distance from Jogjakarta (km)	Boat with engine (pieces)	Number of fishermen (person)	Supporting facilities
Baron	60	70-80	100-150	TPI, Pabrik Es, BBM
Drini	67	30-40	70	TPI, BBM
Ngrenehan	75	40-50	100	TPI, BBM

TPI : Fish Auction Place; Pabrik Es: Ice Fabric; BBM: Fuel Seller

The fishermen generally worked for 8 hours per day, which was differentiated into some activities as follow:

- preparation before fishing (boat and all equipment for fishing) 0.50 hours
- sailing, fishing in the ocean 7.00 hours
- uploading the fishes and parking the boat 0.50 hours

These activities were done by all fishermen in Baron, Drini and Ngrenehan coasts. These activities were classified as hard work that needed energy 3.600 kcal/day.

The engine, which was usually used by the fishermen for driving their boats, was YAMAHA and had power 15 hp. For operating the engine it was needed approximately 20 litre of fuel or gasoline. In one boat there were in average 3 fishermen, who had different jobs. One fisherman served as a driver of the boat and two others had responsibilities to throw the nets into the ocean and to collect the fishes caught in the nets. In normal condition one boat in that operation time could catch fishes 100 kg. The results of the observation were shown in table 2.

Table 2. Conditions of Providing Fresh Fishes in Baron, Ngrenehan and Drini Coast

Coast	Time (hour)	Number of Fishermen (person)	Distance (Km)	Fuel (litre)	Normally catched fishes (kg)	Current catched fishes * (kg)
Baron	7-8	2	1-5	15-25	100-150	30-40
	8	3	5	15-25	100-200	45
	8	3	5-10	15-25	75-200	35
	8-11	2-3	5-10	15-25	100-150	35
	7-9	2-3	3-6	15-25	100-150	30
Ngrenehan	8	3	2-7	15-25	100-200	25-35
	7-8	3	1-5	15-25	100-150	30-40
	8	3	5-10	15-25	100-150	40
	8-9	3	1-7	15-25	100-150	35
	6-8	3	1-6	15-25	100-150	35
Drini	8	3	5-10	15-25	100-150	45
	6-7	3	1-8	15-25	100-150	40
	8	2-3	2-5	15-25	100-150	35
	7-9	2-3	2-6	15-25	100-150	30
	8	2-3	1-5	15-25	100-150	30

Note: Results of catching fishes in August-September 2001 decreased drastically, because of asphalt contamination in Congot Coast on March 2001.

The distance expressed how far the fishermen sailed their boat to catch the fishes. They could catch between 100-150 kg per day, but at the time the research was conducted, the fishes were very rare and the results decreased drastically. It could be caused by the asphalt pollution, which was produced by the ship that was broken down in Congot coast. They said, after the pollution occurred some fishes and sea ecosystem suffered on black colour of asphalt.

The LCA for the fresh fishes, which was ready to sell in the Fish Auction Place, was shown in table 3.

Table 3. Result of LCA for fresh fishes (**per kg fresh fishes**)

	Energy / Emission
Human	3600 kcal
Fuel (gasoline)	7,47 MJoule = 1785,37 kcal
Emission CO_2	0,0385 mg
Emission SO_2	0,116 mg
Emission NOx	0,0743 mg
Particle Polutant	0,0107 mg

If the fresh fishes were processed further into fried or barbequed fishes, the LCA of these products would be different. In the processing of barbequed or fried fishes, one woman worked all of the steps, from cleaning the fishes, giving spices, to frying or barbequeing. It needed 30 minutes. For 1 kg barbequed fish or 1 kg fried fish it needed ca. 250 gram wood or coal. A vegetable oils was added into the pan for frying, but the energy that was used for both process was not different. The result of barbequed or fried fishes was shown on table 4.

Tabel 4. Result of LCA for barbequed or fried fishes (**per kg barbequed fishes**)

	Energy / Emission
Human	62,5 kcal
Fuel (wood)	3,50 MJoule = 836,52 kcal
Emission CO_2	38,10 g
Emission SO_2	0,01825 g
Emission NOx	0,585 g
Particle Polutant	0,7325 g

To evaluate the quality of the fishes the microbiological tests were conducted, especially to detect the presence of pathogenic microorganisms and Total Plate Count (TPC). The results of these tests were presented in table 5.

Table 5. Results of microbiological tests for fresh, barbaqued and fried fishes

Kind of test	Baron Fresh	Baron Fried	Ngrn Fresh	Ngrn Barbeque	Drini Fresh
Total Plate Count	3×10^7	5.2×10^6	8.9×10^6	1.56×10^5	$< 10^5$
E.Coli	Positif	Negatif	Negatif	Negatif	Negatif
Staphylococcus sp	Negatif	Negatif	Negatif	Negatif	Negatif
Salmonella sp	Negatif	Negatif	Negatif	Negatif	Negatif

Based on the results, amount of microorganisms in the fresh fish and products was high but some pathogens depicted negatif result, only the fesh sample from Baron was contaminated by *Escherichia coli*. It meant, the fishes were safe to be consumed but probably there were some other microorganisms which were not detected in this test. This fact was supported by the high value of TPC. The TPC would increase if the processing such as frying and barbequeing was done. During the frying some microorganisms would be killed because of the heat of the vegetable oil which served as medium. In the barbeque the smoke of the wood would give an antioxidant effect, and the heat from the fire could cause the declining of the amount of microorganisms.

CONCLUSION

It was concluded that, for producing 1 kg fresh fish in Gunung Kidul it was needed human energy 3,600 kcal, fuel 7.47 MJ and produced some emissions, CO_2 0.385 mg, SO_2 0.116 mg, NO_x 0.0743 mg and particle 0.0107 mg. For 1 kg barbequed or fried fish it was needed human energy 62.5 kcal, fuel 3.50 MJ and produced some emissions, CO_2 38.10 mg, SO_2 0.0825 mg, NO_x 0.585 and particle 0.7325 mg.

The TPC of fresh fish and products lied between 10^5 – 10^8/g. They were not contaminated from *Escherichia coli, Salmonella* sp and *Staphylococcus* sp, except the fresh fish from Baron coast was contaminated by *Escherichia coli.*

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