The use of consumer behavior to identify the flow mapping of waste cooking oil: A finding from Semarang, Indonesia

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Abstract. Management of waste cooking oil is expected to receive more concern nowadays. As a daily consumed good, cooking oil generates a huge amount of waste. Besides, the potency of WCO to cause environmental damages such as water pollution is also inevitable. Adopting the concept of a circular economy, WCO is actually convertible into other value-added products such as soap or fuel. However, in practice, WCO is at scattered points. This paper identified the flow mapping of WCO in Semarang Indonesia as a baby step before stakeholders arrange the further move. Based on the survey that is conducted to 347 households and 146 culinary enterprises, it is known that 90% of households and 67.6% of culinary enterprises disposed the WCO to drains, land, or trash. There is also a small number of participants who give or sell the WCO to 3rd parties such as garbage collectors, oil collectors, household assistants, relatives, and others. WCO-recycling is only carried out by 0.9% of household and none of culinary enterprises.

1. Introduction
In the last two decades, industries began to put more concern in initiating the practice of sustainable supply chain management (SSCM) [1], [2]. The international trend now is challenging industries to focus on SSCM in achieving competitive advantage [3] by applying this concept in all product life cycle including the end-of-life (EOL) [4]. One of the products with poor EOL management is cooking oil. The issue of inappropriate management of waste cooking oil (WCO) is currently attracting public concern and serious attention in recent years [5]. This is because the production of WCO is always there, noticing that cooking oil is a daily consumed good. In China, which is the largest producer of WCO, fast food restaurants in large cities can produce 15 liters of WCO every day [6]. In Mediterranean countries, one person produces 3-5 kg of WCO every year [7].

Besides the huge amount, another factor that makes WCO kept being discussed is the serious impact caused by the inappropriate management of WCO. High-temperature frying can momentarily eliminate the edible and nutritional value [8], so that re-consuming cooking oil will only endanger food safety and human health [9]. Improper handling of WCO can cause environmental pollution especially for water and soil [10]. On a larger scale, the mistreatment of WCO can also damage the aquatic community as the oil layer in water will cover the surface and inhibit oxygen to diffuse[11].
Seeing the adverse effects on humans and the environment resulted from the inappropriate handling of WCO, there should be procedures for proper management of cooking oil waste. WCO can actually be collected and then used as a biofuel production unit, soap, detergent, paint or lubricant [12]. Not to mention, collecting and recycling this waste is a contribution to solve three problems at once, which are reducing waste, reducing dependence on fossil fuel energy, and reducing pollutant emissions [13]. This concept adopts the concept of the circular economy (CE). The CE concept is when material flow continues to circulate and does not enter the biosphere, except biological nutrition [14]. Today, industries are beginning to see this concept as a mechanism to increase competitive advantage [15]. One of the three CE principles is to keep the product or material used.

Before the concept of CE can be implemented, it is necessary to ensure that the WCO can be collected first. Because in practice WCO is at scattered points such as from households, restaurants, and hotels, so a collecting chain is needed at the very first place [16]. Thus, this paper will contribute in identifying the flow of waste cooking oil as a system portrayal to be considered in formulating the further move.

2. Theoretical Background

2.1. Waste Cooking Oil

WCO is a waste produced from food frying activities using vegetable cooking oil [17]. Some examples of plants that can produce vegetable cooking oil are palm oil, corn, sunflower, olives, soybeans, and peanuts [18]. During frying activity, vegetable oil will be heated at 160-200 ° C for a relatively long time. The condition when frying is done will certainly result in changes both physically and chemically in the cooking oil.

Discharging WCO to the soil or Final Disposal Site is not the right form of handling. Such treatment will only cause water and soil pollution, disrupt aquatic ecosystems, and endanger human health [18]. One liter of WCO discharged into the water stream can contaminate 1000 water tanks containing 500 liters. When it reaches a water source, WCO will form a layer on the surface of the water which inhibits oxygen exchange and leads to changes in the ecosystem. Not only that, the drain pipe will also be blocked by cooking oil waste that accumulated so that it will disrupt the flow of the wastewater and cause unpleasant odors or various diseases [19].

WCO is potential to be converted into soap, as a raw material for oil or oleochemical processing industries [20], as energy sources such as biodiesel, bio methanol, hydrogen, H2 / CO, and low molecular weight hydrocarbons [21]. Seeing the business opportunity behind this waste stream, some companies have even invested in collecting WCO to be further processed [13].

2.2. System Description

Based on the Report on the Distribution of Indonesian Edible Oil Commodities published by the Central Bureau of Statistics in 2016, it is known that the circulation of cooking oil in the province of Central Java is the largest in households. Because 89.55% of cooking oil from distributors will continue to retailers, and 69.37% are sold to households [22].

Unlike the distribution of cooking oil, the flow of WCO's EOL in Central Java is no recapitulated yet. This is because no stakeholder is responsible for the WCO collection. Unlike the domestic waste that has a National Waste Management Information System managed by the Ministry of Environment and Forestry of the Republic of Indonesia, the data on waste cooking oil produced has also not been recorded. Organizations related to waste cooking oil such as the Association of WCO's Collector for
Indonesian Renewable Energy (APJETI) also do not provide much information. Even the Semarang branch of APJETI can no longer be contacted.

3. Research Design

The objective of this research is to perform a flow mapping of WCO in Semarang, Indonesia. A survey was conducted in Semarang, Indonesia. It is the capital city of Central Java Province. This city currently has not implemented WCO collection yet and is considered as one of the cities that is believed to have a rapid development associated with the food business. The questionnaire that was used in this survey has two sections consisting of the respondent’s personal information in the first section and the respondent’s behavior in managing the WCO in the second section. Respondents of the survey are household and culinary enterprise's owners. The questionnaire is designed differently for household and culinary enterprises. For the first part of the household, the information conveyed is the respondent’s name, gender, age, educational background, marital status, income (in IDR) per month, and the location they live. Meanwhile, for the culinary enterprise, the information includes the kind of food they sell, monthly income, and the location of the food trucks. In the second section for both culinary and household. The participants were asked about the intensity of reusing the oil, the treatment for the WCO, the amount of WCO generated, and their understanding of the harm. To generate the mapping, the percentage of each answer is first counted.

4. Findings and Discussion

The survey was performed to 347 households and 164 culinary enterprises in Semarang. 47% of household reuses the same cooking oil twice, 23.3% once, 17.9% do not reuse, 10.4% 3 times and 1.4% more than 3 times. This information showed in Table 1. In the after-use phase, 97.7% of household produces WCO, while the other 2.3% does not produce WCO. Of the 97.7% of the waste produced, the most common behavior is to dispose the waste cooking oil with the details 66% to the drains, 8.6% to the land, and 15.8% to the trash. If it is proportionated to the amount of WCO generated in Semarang, there are 252,271 liters of WCO ended up in water. This is because not everyone understands the impact caused by WCO’s mistreatment. Only 54.9% of the participants understand the dangers of disposing WCO to landfills. In addition, many households who dispose the WCO to drains claim that it is the easiest and most practical way because they only need to pour the leftover cooking oil directly from the frying pan into the sink when doing the dishes. The little amount of leftover oil makes them think that the impact will not be significant. In fact, if that little amount of WCO is collected for the whole month, one household produces 0.973 liters of WCO.

Another behavior is to give the WCO to other parties. Other parties that receive the WCO are varied, such as garbage collectors, household assistants, culinary enterprises, friends or family, Waste Bank (Bank Sampah), and Woman Association (PKK). Besides being given, some, such as culinary enterprises, sell the WCO to other parties. The cooking oil that was sold was only used for one-time cooking. Recycling the WCO was only carried out by 0.9% of the participant. Some of these wastes are used as fuel to turn on kerosene lights, make chicken feed, or become fence lubricants. This is described in Figure 1.

26.6% of culinary enterprises claimed that they never reuse the cooking oil. 24.4% reuses 3 times, 22.6% 2 times, 18.3% more than 3 times, and 8.5% 1 time. In contrast to the domestic sector, in the culinary sector, more participants do not produce any leftover oil after-use, which is 13.4%. This is described in Figure 2.

After-use behavior of cooking oil between culinary enterprises and households is more likely the same. The most common behavior is to dispose of cooking oil waste. 31.7% dispose it into the drains, 11.6% throw it to the land, and 24.4% dispose it in the trash. There is no culinary enterprise who can afford to recycle the WCO. Aside from being disposed, 9.8% sell it to other culinary enterprises, oil
sellers or collectors, military academy (KODAM), a traditional market, friends, family, and other
9.1% gave to oil collectors, garbage collectors, friends, family or using it again for cooking at home.
The data used in the mapping is entirely sourced from the results of the questionnaire, so that it is
prone to being subjective. For example, in the amount of cooking oil waste produced, respondents’
answers often still use estimation such as referring to the size of mineral water bottles without any
field observation used to find out the amount of cooking oil waste produced.

Table 1. The Result of The Survey

| Household | Culinary Enterprise |
|-----------|---------------------|
| Intensity of cooking oil re-usage | Intensity of cooking oil re-usage |
| Never reuse | 62 | 17.87% | Never reuse | 43 | 26.22% |
| 1 time reuse | 81 | 23.34% | 1 time reuse | 40 | 24.39% |
| 2 times reuse | 163 | 46.97% | 2 times reuse | 37 | 22.56% |
| 3 times reuse | 36 | 10.37% | 3 times reuse | 14 | 8.54% |
| >3 times reuse | 5 | 1.44% | >3 times reuse | 30 | 18.29% |

| Behavior of WCO management | Behavior of WCO management |
|---------------------------|---------------------------|
| Dispose to drains | 229 | 65.99% | Dispose to drains | 52 | 31.71% |
| Dispose to trash | 55 | 15.85% | Dispose to trash | 40 | 24.39% |
| Dispose to land | 30 | 8.65% | Dispose to land | 19 | 11.59% |
| Recycle | 3 | 0.86% | Give to other parties | 14 | 8.54% |
| Give to other parties | 21 | 6.05% | Sell to other parties | 16 | 9.76% |
| Sell to other parties | 1 | 0.29% | Do not produce leftover | 23 | 14.02% |
| Do not produce leftover | 8 | 2.31% |

Figure 1. The WCO Flow Mapping of Households

Besides, specifically in culinary enterprises, there appears to be a difference between the information
from the respondents and the results of the observations. In some cases when the frying pan can be
seen, for example when conducting an interview with a Sempolan seller, the oil used for frying looks
dark brownish, but when filling out the questionnaire, business owners said that they only re-use the cooking oil once. There are two things that are thought to be the cause of this. First, because the respondent misinterprets the question, or because the respondent feels that this should not be known to the public so the answers given do not really reflect the actual conditions.

Figure 2. The WCO Flow Mapping of Culinary Enterprises

5. Conclusions, Limitations, and Future Research Directions
The objective of this study was to identify the flow mapping of WCO in Semarang. Based on a practical perspective, this study could give such insight to the stakeholders, for example, local government of Semarang in formulating the further treatment of WCO since proper handling of WCO is considered as essential [10], [11]. Based on the theoretical point of view, this study could give such a contribution toward the related literature of waste flow mapping especially for waste cooking oil in Indonesia.

The result of this research stated that most of the households or culinary enterprises have not managed the WCO well. For households, 66% discharges WCO to the drains, 8.6% to the land, and 15.8% to the trash. This number is as much as 252,271 litres of WCO that ends up in water source. Meanwhile from culinary enterprises, 31.7% discharges WCO to the drains, 11.6% to the land, and 24.4% to the trash.

The limitations of this study are twofold. First is related to the accuracy of the culinary enterprises’ answer as there is no access to observe the cooking and waste managing activity. For the upcoming research, a field observation is expected so it can confirm the answer from the respondent. The second limitation is related to the area (location) of this research, i.e., the study was conducted in Semarang, Indonesia. As suggested for future research is a research with a larger sample size so that more detailed analysis would be obtained. In addition, a more nationally representative sample, not only geographically but also demographically, could provide higher generalizability. Therefore, to generalize, the upcoming research should broaden and expand the research area.
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