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Potential Analysis and Distribution Flow of Waste Cooking Oil in Bali Province

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A B S T R A C T

Waste Cooking Oil (WCO) is a hazardous and toxic that has a negative impact on the environment. WCO becomes a potential if it managed properly, because it can be processed into products that have an economic value. The purposes of this research were to present data the use of cooking oil in the Province of Bali, the handling carried out, the distribution flow of WCO, public expectation and responses regarding the wasted cooking oil collection system. The research stage begins with an initiation, collecting data of respondent, processing and analyzing data. Data collection was conducted using questionnaires and interviews. The sample used was 365 respondents consisting of household respondents, hotels, restaurants, cafes, food-based SMEs, catering and street vendors. The results showed that the use of cooking oil in Bali is not less than 3,050.052 liters/month which will produce WCO not less than 1 million liters/month. The data obtained were then analyzed descriptively. In handling and distribution of WCO, it was found that 91% of respondents disposed of their WCO, and 6% was distributed to collectors or waste banks and the rest was processed themselves to make products such as candles. Then 98% of respondents hope and are willing to support the government to create a WCO management system, where WCO can be collected by villages or waste banks for households and collectors who have permits/legality for non-household WCO. This research provides positive information for the government, so that in the future WCO can be managed properly and provide added value for environmental, social and economic aspects.

Introduction

Nationally, In 2019 the need for cooking oil, especially palm oil for the food category, reached 9.86 million tons, or an increase of 49% from the previous year (Rahayu *et al.*, 2020). Due to public consumption and the food industry using a lot of cooking oil in its processing, that affected the increase in the need for cooking oil (Emelike *et al.*, 2020). The increasing demand for cooking oil has the potential to produce more waste cooking oil. Waste Cooking Oil (WCO) is oil and fat that has been used for cooking or frying in the food processing industry, restaurants, fast food and at the consumer or household level (EUBIA, 2020). According to Loizides *et al.*, (2019), WCO or also

known as waste cooking oil is vegetable or animal oil that has been used to cook food and has reached the point where the oil is no longer suitable for use.

WCO, if not managed properly, has the potential to pollute the environment, marked by increased levels of Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) in the waters (Potgieter *et al.,* 2004; Hidalgo-Crespo *et al.,* 2020). Judging from its chemical composition, WCO contains compounds that are carcinogenic which are formed during the frying process. Carcinogenic compounds that arise during the frying process are acrylamide, a compound that appears due to the high temperature heating process (above 120^{o}C) in foods containing carbohydrates. The Food and Drugs Administration (FDA) classifies acrylamide compounds as compounds that cause cancer in humans (Sengke *et al.,* 2013; Carrabs *et al.,* 2014; Lee *et al.,* 2020). Currently, proper handling and management of WCO is mandatory, even in some countries the issue of WCO has become the subject of political discussion (Mannu *et al.,* 2020; Tsai, 2019).

Data in 2018 showed that the total consumption of cooking oil for the population of Bali Province is 4,735,057.2 liters/month (BPS, 2019). Based on a 2019 survey conducted by (Yuarini *et al.,* 2021) with several community components, namely housewives, caterers and hotel/restaurant owners, it was stated that the use of cooking oil generates about 30% WCO.

A value of 30% has also been reported by Syahdan *et al.,* (2017). WCO in Bali comes from several main sources that contribute in large numbers, such as households, hotels, restaurants, cafes, and industries/MSMEs engaged in the culinary field.

The abundant potential of WCO, which is around 3,314,540.04 needs to be managed properly. But so far, the management of this potential WCO has not been regulated and in Bali it is known that there is only one foundation, namely the Lengis Hijau Foundation which manages the WCO with a capacity of only 20,000 liters per month.

In order to find the pattern of WCO management and its utilization, it is necessary to conduct a study on the handling of WCO in the Bali Province, because so far, it has not been widely reported in scientific articles in detail. In addition, the effect of the COVID-19 pandemic on the pattern of using cooking oil in Bali Province has never been reported. Through this initial mapping, later the WCO can be projected to be processed into products that have economic added value, so that it is expected to prevent or reduce environmental pollution which indirectly also has an impact on health. Many studies have reported that WCO has the potential to be processed as derivative products such as biofuels (Chrysikou *et al.,* 2019; Hazrat *et al.,* 2019; Moulita *et al.,* 2020); bio-lubricant (Abdulbari *et al.,* 2011; Karmakar *et al.,* 2017); and animal feed ingredients (Tres *et al.,* 2013). WCO can also be processed into paraffin, transesterification products, and other value-added products (Panadare & Rathod, 2015); bath soap (Sanaguano-Salguero *et al.,* 2018); and candles (Rezaei *et al.,* 2002). Some of the products mentioned above, such as candles and soap, can certainly be used as tourism supporting products (souvenirs) in Bali. This study aims to determine the amount of cooking oil used in the province of Bali, the handling of WCO carried out, the distribution flow of WCO, the expectations and responses of the community regarding the WCO collection system.

Materials and Methods

The tools and materials used in this research are work stationery, questionnaires, cell phones and cameras as tools for documentation of the entire research process. There are several stages of research in this research. First stages was Preliminary Stage. This research was conducted in April – October 2021, carried out in 9 districts/cities in Bali in the province. The preliminary stage in this research is identification and problem formulation.

The second is to determine the objectives and limitations of the research based on the conditions that occur in the field and then a literature study is

carried out to support the research to be carried out. The second stages was Data Collection Stage. The data needed in this study are primary data and secondary data. Primary data was obtained through two stages, namely interviews and questionnaires to the respondents. The primary data needed include data on the use of cooking oil, handling of WCO and community responses to the WCO collection system. The population of this study is cooking oil users which consists of several categories of sources, namely households, hotels, restaurants, cafes, food-based SMEs, catering and street vendors in Bali Province whose number is unknown. The sampling technique used is a non-probability sampling technique. The method used is the Snowball Sampling Method. Determination of the number of samples using the Lemeshow method which is one method that can be used to calculate the number of samples whose population is large and the exact number is not known (Lemeshow *et al.*, 1990). Here is the Lemeshow formula:

$$n = \frac{z_{1-\frac{\alpha}{2}} P(1-P)}{d^2}$$

Information:

n = Number of samples

z = z score at 95% confidence = 1.96

p = maximum estimate = 0.5

d = alpha (0.10) or sampling error = 10%

Based on the calculation results obtained the number of samples as much as 96, which is the minimum number of samples used. The sample used in this study was 365 respondents covering all source categories. Secondary data obtained from other parties in the form of articles, scientific journals, and books. The last stages was Data Processing and Analysis Stage. The data obtained were then tabulated using Microsoft Excel and analyzed descriptively. The source data for WCO are grouped into two, namely household WCO and non-household WCO. Data on the use of cooking oil is grouped by use before and after the Covid 19 pandemic, in order to know whether the pandemic has an impact on the use of cooking oil. The WCO handling data analyzed is the repetition of using cooking oil in one pour, the percentage of WCO remaining and then whether the WCO is processed, distributed to certain parties or discarded. Next data analyzed is the distribution flow of WCO, which is based on the number and related stakeholders.

Results and Discussion

Identification of Cooking Oil Usage

The potential for WCO in Bali Province is calculated based on the average use of cooking oil from each source, the behavior of using cooking oil and handling of residual cooking oil (WCO). The dominant cooking oils used in Bali are Palm Oil (62%) and Coconut Oil (32%). The average data on the use of cooking oil for each source before and after the Covid 19 pandemic can be seen in Figure 1.

Based on Figure 1, information is obtained that the impact of the Covid 19 Pandemic on the average use of cooking oil in Bali Province is quite large in hotels and home industries. In hotels, the average use of cooking oil fell by 70%. Since the closure of flights to and from Bali and the implementation of the Community Activities Restrictions Enforcement (CARE), the tourism sector in Bali has become paralyzed. BPS data for 2020 shows the number of hotels of all classes in the province of Bali is 380, down from 507 in 2019. The decline in the number of hotels is caused by operational expenses due to a decrease in the number of tourist visited, average length of stay and room occupancy rate. The number of tourist visits to Bali decreased by 82%, namely 6,275,210 tourists in 2019 to 1,069,473 tourists in 2020. The decline also occurred in the average length of stay which was originally 2.84 days in 2019, down to 2,79 days in 2020. Room occupancy rate experienced a drastic decrease from the previous average of 59.57% in 2019 to only 15.62% in 2020. These three factors caused the decrease in

the average amount of cooking oil usage which in initially as many as 48,412 liters/month down to 14,375 liters/month. In contrast to hotels, the number of restaurants and cafes actually increased from 2,984 in 2019 to 3,233. This is in line with the results of a survey conducted by GrabFood Indonesia, which reported that there was a 65% growth for the food and beverage industry in Indonesia in 2020 when compared to 2019 (Kontan, 2021). When calculated, the average use of cooking oil for restaurants and cafes in Bali is 22,631 liters/month during the pandemic.

Based on Figure 2. The average use of cooking oil in one pour is in the range of 1-3 times. Hotels use cooking oil no more than 2 repetitions, while other sources use an average of 2 times and at street vendors, cooking oil is used 3 times in one pour. Repeated use of oil, especially after 1-2 times of frying should be avoided because changes in the physico-chemical properties of the oil affect the quality of the oil forconsumed by humans (Idun-Acquah *et al.,* 2016). In contrast to hotels and restaurants, the use of oil in households tends to be quite stable although it has decreased slightly from 2.89 liters/month to 2.76 liters/month, although this value is still smaller than the national consumption value of 11.54 liter/capita/year or 3.85 liter/month.

Research conducted by (Tanaem & Ernah, 2021) also reported that the Covid 19 pandemic did not affect the amount of cooking oil consumption by households in the city of Bandung. The current population of Bali Province is 4,317,404 people (BPS, 2021) where on average 1 household consists of 4 people (BPS, 2021). Based on the explanation above, the biggest potential for WCO in Bali Province is coming from households.

WCO Handling

The handling of WCO in Bali Province can be grouped into two, namely the handling carried out by households and non-households. The handling in question includes the frequency of repetition of the use of cooking oil and WCO produced. The frequency of repetition of using cooking oil is presented in Figure 2 and the resulting WCO is presented in Figure 3.

The most ideal cooking oil is used once, but it is still feasible to use a maximum of three times (Mustinda, 2017). Research conducted by khoirunnisa *et al.*, (2019) reported that cooking oil experienced a change in chemical structure after three times of frying, namely increasing the number of peroxides and acids free fat contained. Halim *et al.*, (2016) also reported the same result, that repeated frying will increase the content of peroxide and free fatty acids.

Figure 3 shows the WCO generated by each source. The WCO produced is in the range of 38-45% of the cooking oil used. If it is associated with Figure 2, the hotel with the lowest repetition frequency of 1.8 times actually produces quite a bit of WCO, which is only 39% of the cooking oil used.

This is presumably because the hotel cooks in large enough quantities, so that the remaining WCO produced tends to be small. Similar results were obtained by (Mensah & Obeng, 2013) who conducted research on the use of cooking oil in hotels in the city of Accra, Ghana, where the remaining WCO produced was 34%.

Other sources tend to have more or less the same pattern and results, except for street vendors who use cooking oil repeatedly up to 3 times, leaving only 38% of WCO. Most of the street vendors use oil many times for frying before throwing it away to reduce costs (Ngozi *et al.,* 2019; Halim *et al.,* 2016). Research conducted by Mensah & Screwdriver, (2013) shows that vegetable oil is used by street vendors for frying 3-6 times before being disposed of.

The oil will be removed when it becomes dark, foamy, and odor. Based on the explanation above, it is important to conduct regular socialization and education on the dangers of WCO for health and the environment as well as the benefits that can be obtained if WCO is managed properly.

WCO Potency and Distribution

In 2021, The potential for WCO in Bali Province tends to be greater than in previous years due to the increasing number of residents who are the biggest contributor to the WCO produced. If in 2017-2019 the average WCO produced was 30% from the use of cooking oil, this year it will increase to 40%. This means that people are starting to realize and understand the dangers of using cooking oil repeatedly which can cause health problems and even cause cancer (Ganesan *et al.*, 2019). The impact of the Covid-19 pandemic is indeed very significant for the tourism sector as seen from the decrease in the use of cooking oil from hotels, restaurants and cafes (horeca), but overall it does not have much effect on the potential supply of WCO. Households have a potential supply of not less than 1,191,604 liters/month, while horeca has a potential supply of not less than 14,803 liters/month and from SMEs, street vendors and caterers which have a potential of no less than 35,000 liters/month.

Problems arise when it is known that 91% of households dump their WCO into the ground or sewer. This is a challenge in the future how to manage, so this potential can be optimized (Kharina *et al.*, 2018). Proper handling of WCO by not dumping it directly into the ground or sewer will prolong the life cycle and prevent groundwater contamination (Ramos *et al.*, 2013). Only a small number of households channel their WCO through waste banks, the Lengis Hijau Foundation or WCO collectors whose legality is still questionable. Most hotels have partnerships with collectors whose identities have not been disclosed. Sources in the field said the collectors came from Surabaya. WCO is sold at a price of Rp. 2.500 – Rp. 4,000. The distribution flow of WCO is presented in Figure 4. A small portion of WCO originating from households is channeled to the waste bank. Several waste banks process the WCO into candles and soap, others distribute the WCO back to the Lengis Hijau Foundation which is then processed into soap (still in the development stage), candles which are sold to several cafes and hotels in Bali and biodiesel which is sold to the Green School for recycling, used as fuel for school buses. The waste bank also distributes its WCO to collectors in Bali, but the allocation is not yet known. Non-household WCO, which is a small portion of horeca, distributes WCO to the Lengis Hijau Foundation. Other sectors and most of the horeca distribute WCO to collectors in Bali or also in Surabaya, where these collectors also distribute their WCO to larger collectors and some of them export the WCO. The export price of WCO Bali is at Rp. 5.000, - while some other areas such as DKI Jakarta is at Rp. 7,500, - and in West Java in the range of Rp. 3,000, - up to Rp. 7,000, - (Cash Industry, 2021).Some collectors only collect and distribute WCO, but there are also those who process the WCO into biodiesel and some even purify the WCO for resale to the market in the form of bulk cooking oil. The Caritas Switzerland survey, as quoted by Christensen, (2012), shows that 50-60% of WCO produced in hotels and restaurants in Bali is reused for food. No less than 9,000 liters of recycled oil are used for cooking in Bali in one week. Recycled cooking oil is sold for IDR 5,000 to IDR 7,000 per liter to the community, mainly from fried food entrepreneurs on the roadside (Syam *et al.*, 2018). Respondents really appreciate if the government takes strategic steps to manage WCO in Bali Province. 98% of respondents strongly support if the government establishes a clear rule regarding the procedures for managing WCO. Most of the household sector wants WCO to be managed by the village and the rest through a waste bank or both.

They are ready to collect their WCO within a certain time or volume by being picked up at their respective homes. The non-household sector wants WCO to be channeled through a legal institution, both managed by the government and the private sector. Socialization and education to all sources, especially households, need to be carried out regularly so that there is no misinformation or understanding. De Feo *et al.*, (2020) in his research stated that the failure of the WCO management program in Angri City, Italy was caused by the low participation of the community who were still not properly socialized and educated.

Fig.1 Average Waste Cooking Oil (WCO) in Bali Province by Each Source

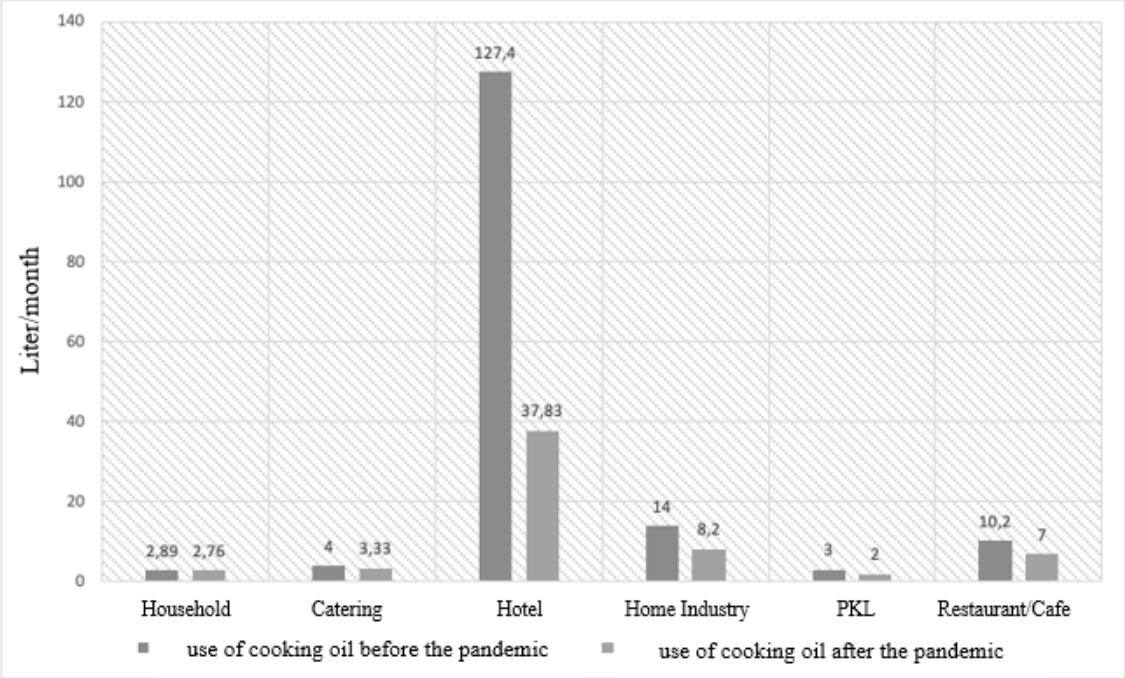


Fig.2 Repeated Use of Cooking Oil (one pour)

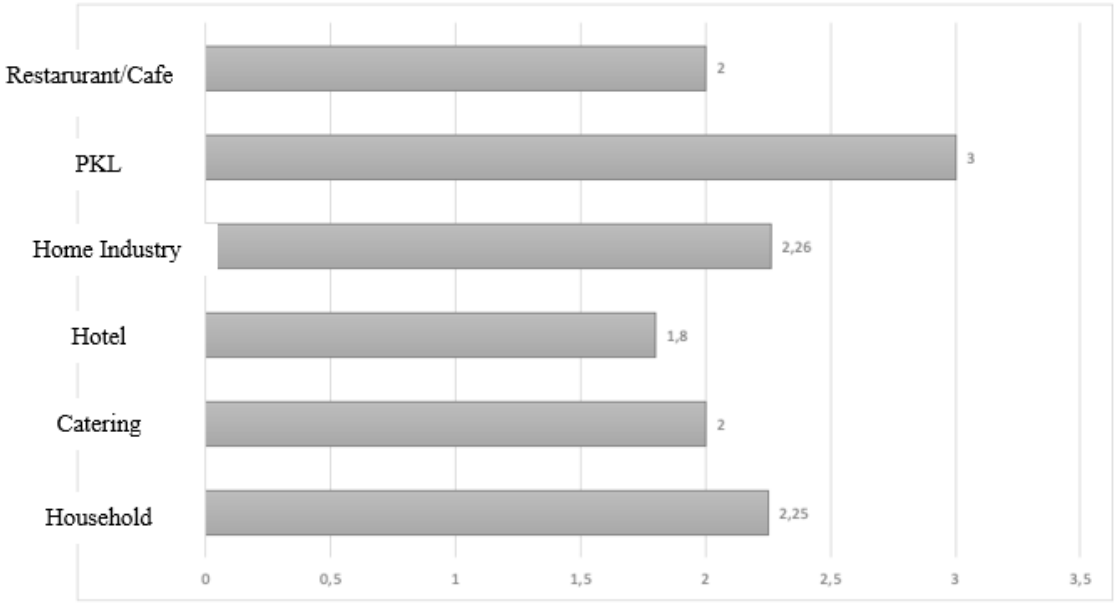


Fig.3 WCO generated

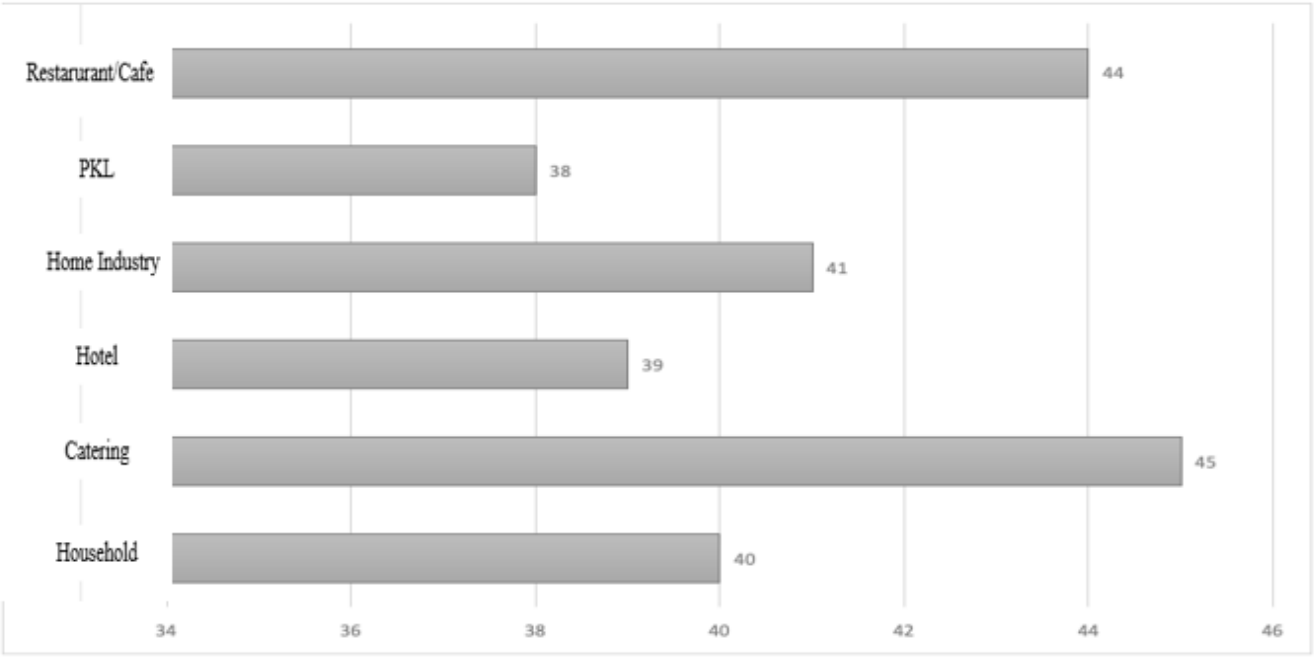


Fig.4 WCO Distribution Flow in Bali Province

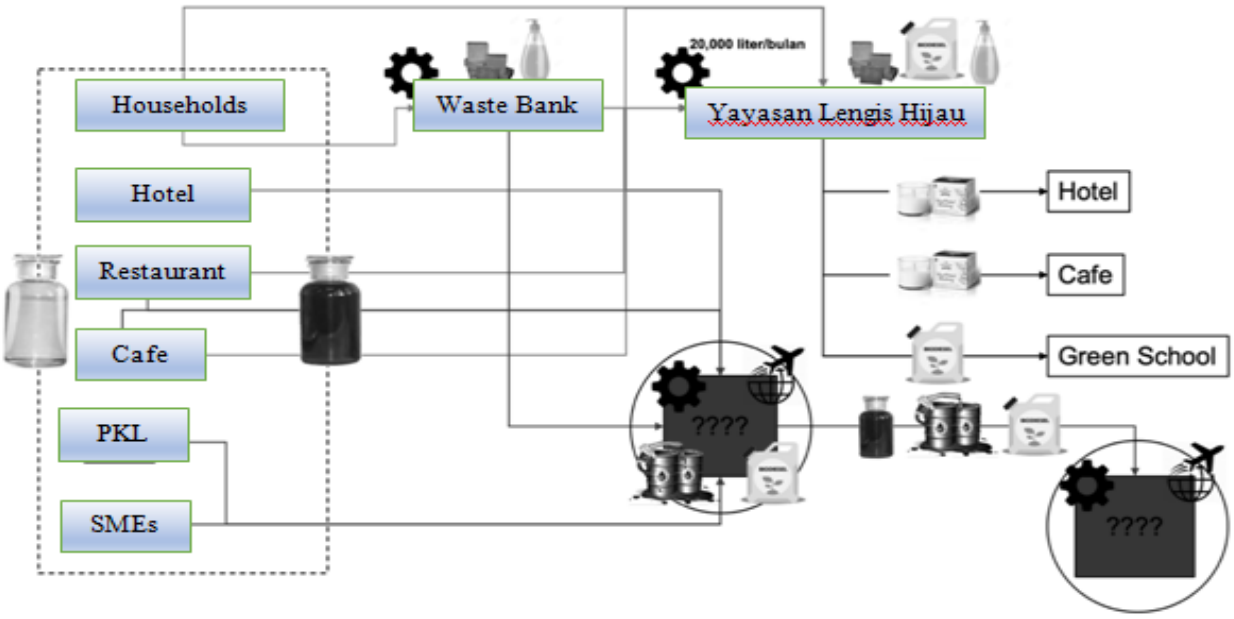
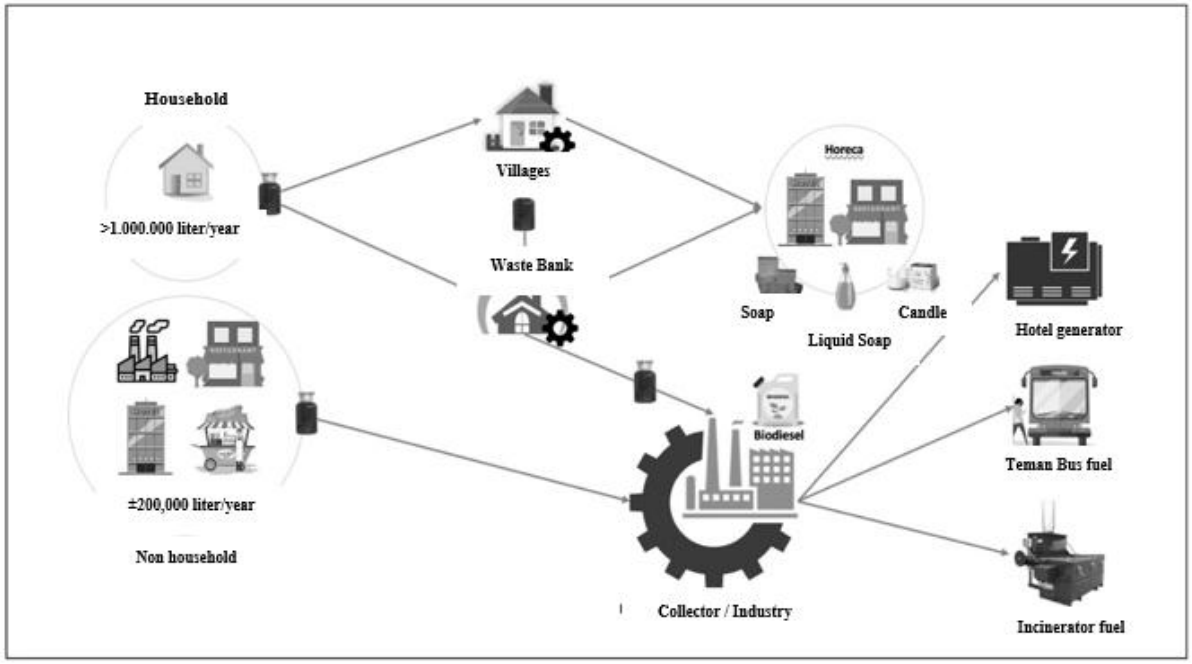


Fig.5 The distribution pattern of WCO in Bali Province that can be adopted



The Bali Provincial Government may consider or adopt the Regulation of the Governor of the Special Capital Region of Jakarta Number 167 of 2016 concerning Cooking Oil Waste Management as an approach to managing WCO produced by industry/business (non-household) and Governor of Bali Regulation Number 47 of 2019 concerning Waste-Based Management.

Sources as an approach to managing WCO generated by households. WCO can be managed with the distribution flow presented in Figure 5.Pergub DKI Jakarta Number 167 of 2016 contains points that can be adopted in drafting regulations for the management of WCO in the Province of Bali. In general, this Pergub regulates and controls the management of WCO produced by industry/business in accordance with what is stated in Article 5 concerning Waste Cooking Oil Producers, in paragraph 2 it is stated that what is meant by producers are restaurant businesses, hotel businesses, food industries and user businesses, other cooking oil. Several important points in the Pergub are on the aims and objectives, scope, requirements of relevant stakeholders and reward and punishment. At the point of intent and purpose, it can be seen that in DKI Jakarta, the direction of utilization of WCO is to become biodiesel, while plans that can be developed for the use of WCO in Bali Province, apart from being processed into biodiesel, will also be processed into tourism supporting agro-industry products, namely aromatherapy candles and liquid soap.

The next point is the scope where the emphasis is on regulating the management of WCO including producers, collectors, and users. The province of Bali can add perhaps one more element, namely processors, for industry or later for MSMEs that will process WCO into derivative products.

The next point is about the requirements of each stakeholder mentioned earlier. DKI Jakarta has the One Stop Integrated Service Agency and the Regional Environmental Management Agency which are the axis in the management of WCO. The One Stop Integrated Service Agency regulates all matters concerning permits and requirements in the WCO management chain, while the Regional Environmental Management Agency acts as a

supervisor for the implementation of WCO management. These institutions need to be established in the Province of Bali, whether it is necessary to create a special institution or can be directly managed by the relevant OPD in the Province of Bali. The next point is reward and punishment, stakeholders who meet the criteria will be proposed to get awards in the fields of Tourism, Environment and Health while stakeholders who violate and do not comply with the regulations will be subject to sanctions for temporary suspension of business activities until business closure. This point can also be adopted in regulations that will be drawn up in the Province of Bali.

Bali Governor Regulation Number 47 of 2019 can be taken into consideration because at the point of the Gubernatorial Regulation it is stated that this Pergub aims, among others, to improve the quality of the environment, improve public health, make waste economically valuable and increase the role of Producers, Traditional Villages, and Villages in waste management. The approach used is that WCO is waste that is classified as specific waste containing B3 (Hazardous and Toxic Materials) which has also been stated in Clause 4 regarding the types and sources of waste. Another important point in this Pergub is the involvement of the community and Traditional Villages in waste management, so that it can be used as a basis for regulating the collection or distribution of household WCO.

The province of Bali has the potential for WCO of around 1 million liters/month from the average use of cooking oil of 3,050.052 liters/month with the largest supply coming from households. The distribution flow of WCO in Bali Province is still not fully known, because access is constrained. Respondents, both household and non-household, are very supportive if the government makes regulations regarding the management of WCO. The potentials and constraints that are owned must be managed properly based on a clear regulation, so that WCO can provide added value not only from an economic perspective but also from a social and environmental perspective.

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