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Circular Economy Approach to the Management of Used Cooking Oil for Biofuel Production

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Abstract: *The management of used cooking oil (UCO) in the framework of a circular economy presents numerous environmental and economic benefits. This study aims to explore how the implementation of circular economy principles can enhance UCO management for biofuel production.. Methods: The research adopts a mixed-method approach, combining a literature review with empirical data analysis to examine the involvement of key stakeholders, such as households, waste banks, collectors, and biofuel producers. Results: Findings reveal that UCO management not only reduces environmental pollution through waste minimization but also creates economic opportunities across the supply chain. The study highlights the transformation of UCO from waste to a valuable resource, aligning with the concepts of reduction, reuse, recycling, refurbishing, and renewal. Further, policy support, public awareness, and technological innovation are identified as critical factors for effective UCO management. Conclusions suggest that the integration of circular economy practices in UCO management facilitates the transition to renewable energy sources, contributes to carbon emission reductions, and promotes sustainable economic growth. Implications: This research emphasizes the importance of multi-stakeholder collaboration, regulatory frameworks, and continuous evaluation to optimize UCO's role in achieving broader sustainability objectives.*

Keyword: *Used Cooking Oil, Circular Economy, Biofuel, Waste Management, Sustainability*

INTRODUCTION

The management of used cooking oil (UCO) has become an increasingly important issue in the context of sustainable development. In Indonesia, the use of cooking oil in households, the food industry, and the commercial sector generates a significant amount of UCO annually. Improperly managed, UCO poses potential health and environmental hazards. Studies have shown

that the indiscriminate disposal of UCO can contaminate soil and water, damage aquatic ecosystems, and adversely affect groundwater quality, impacting communities that rely on these resources (Cheng et al., 2020). Additionally, reusing UCO as cooking oil without proper recycling processes can lead to health risks such as cancer and metabolic disorders due to the accumulation of harmful compounds, including trans fatty acids and carcinogenic substances (Liao et al., 2019). According to Ardila and Halim (2021), millions of liters of UCO are produced in Indonesia, with a large portion either being improperly disposed of or reused for cooking.

However, from an economic perspective, UCO management offers potential value creation for both communities and industry. When collected and processed into biodiesel, UCO can serve as a renewable energy source with a smaller environmental footprint. Biodiesel derived from UCO has been shown to have a significantly lower carbon footprint compared to fossil fuels, contributing to efforts in reducing greenhouse gas emissions (International Council on Clean Transportation, 2021). Moreover, the management of UCO creates economic opportunities, benefiting households, waste banks, and processing industries, thereby increasing income and generating new employment opportunities (Nasution et al., 2018).

From a social standpoint, UCO management encourages public participation in circular economic activities. By establishing systems for UCO collection and recycling, communities are actively engaged in environmental stewardship. This aligns with the circular economy concept, which emphasizes resource reutilization and waste reduction. Public education and awareness-raising are critical success factors for UCO management, as well-informed communities are more likely to be concerned about the adverse effects of improper UCO disposal and willing to contribute to recycling systems (Mansor & Khamis, 2022). Therefore, a comprehensive analysis of the application of the circular economy framework in UCO management, including the stakeholders involved, is necessary. This approach not only offers environmentally friendly solutions but also creates economic and social opportunities.

METHOD

This study employs a mixed-method approach, combining qualitative and quantitative methods to provide a comprehensive analysis of used cooking oil (UCO) management for biofuel production within the circular economy framework. First, a literature review was conducted to examine existing research, policies, and frameworks related to UCO management, biofuel production, and circular economy principles. This review provided foundational knowledge, identified key factors influencing UCO management, and highlighted best practices for implementation.

The empirical part of the study involved collecting primary data through in-depth interviews. In-depth interviews were conducted to various stakeholders, including households, restaurants, waste banks, collectors, and biofuel producers, to gather insights on current UCO practices, challenges, and potential economic opportunities. In addition, in-depth interviews were conducted with selected key informants, such as government officials, industry representatives, and community leaders. These interviews provided a deeper understanding of the regulatory environment, technological advancements, and social attitudes towards UCO management.

Finally, the findings from in-depth interviews and literature reviews are utilized to analyze the use of used cooking oil (UCO) for biofuel production within a circular economy framework. The role of each stakeholder is also examined across different stages of UCO management The role of each stakeholder is examined across different stages of UCO management and further analyzed from economic and policy perspectives. The results provide a basis for recommendations to enhance UCO management through a circular economy perspective.

RESULTS AND DISCUSSION

Implementation of Circular Economy

The management of used cooking oil (UCO) initially started as a social initiative focused on maintaining environmental cleanliness at the household and waste bank levels. However, it soon revealed a significant economic potential. At the outset, the collection of UCO aimed to prevent its improper disposal, which could pollute water channels and damage aquatic ecosystems. Waste banks facilitated the collection by offering incentives, such as exchanging UCO for goods or money. This initial approach primarily focused on raising awareness about waste management and local environmental hygiene.

Over time, UCO management uncovered substantial economic opportunities. What was once considered waste is now identified as a valuable raw material for biofuel production, especially biodiesel. Waste banks sell the collected UCO to intermediaries, providing a new source of income for both households and collectors, turning UCO management into a viable livelihood. From an economic perspective, these intermediaries play a crucial role in the biofuel supply chain, linking UCO producers to a broader market

On a larger scale, the collected UCO is exported to European countries, where the demand for renewable fuel is growing due to strict carbon emission regulations. Large-scale entrepreneurs benefit economically from exporting UCO, which is processed into environmentally friendly biodiesel compliant with international standards like the European EN 14214. This process significantly enhances UCO's economic value, shifting its perception from mere waste to a high-value commodity.

Theoretically, this transition can be explained through the concept of the circular economy. In a traditional linear economic model, products are discarded after a single use, with no consideration for their potential value. However, the circular economy emphasizes reuse, recycling, and converting waste into valuable resources (Ellen MacArthur Foundation, 2013). UCO exemplifies waste that, with a well-designed system, can be collected, processed, and reintroduced as a valuable product, such as biodiesel. This process also creates new job opportunities across different levels, from households to collectors and exporters.

This approach aligns with the Theory of Planned Behavior (Ajzen, 1991), which highlights the importance of attitudes, social norms, and perceived behavioral control in shaping individuals' intentions. Initially, UCO management might be perceived as a social obligation to maintain environmental cleanliness. However, with the introduction of economic incentives derived from UCO collection and processing, the community's behavioral control shifts. People start to view this activity not only as a social responsibility but also as an economic opportunity that can enhance their welfare. Social norms also evolve as more households and intermediaries participate, fostering a community that is both environmentally conscious and economically productive.

Overall, UCO management has evolved from a purely social effort into a sustainable economic activity involving various actors in the value chain. Locally, households and collectors gain direct economic benefits, while on a larger scale, UCO exports contribute significantly to the economy of large businesses and the biofuel industry. This development illustrates how well-managed waste can transform into a valuable resource, promoting both economic and environmental sustainability. The evolution of UCO management from a social and environmental initiative to a high-value economic activity is closely related to the concept of the circular economy. Unlike the traditional "take, make, dispose" linear model, the circular economy aims to keep materials within the economic cycle for as long as possible through reuse, recycling, and regeneration (Ellen MacArthur Foundation, 2013).

In the context of UCO management, what was once considered valueless waste, potentially harmful to the environment, is now repurposed as a valuable raw material. With the circular economy framework, UCO collected by households, intermediaries, and waste banks no longer ends up in landfills or pollutes waterways. Instead, it serves as an input for biodiesel production, a renewable energy source. This approach reflects one of the core principles of the circular economy: maintaining the value of materials in the economic cycle. UCO is processed and reused as biodiesel, which carries economic and environmental benefits. Additionally, this model encourages the redesign of waste management systems to focus not only on disposal but also on creating value from waste (Stahel, 2016).

The circular economy model has positive implications for job creation and income generation. UCO collection creates economic opportunities for households, waste banks, and intermediaries. On an industrial level, large-scale businesses managing UCO exports to international markets gain even greater economic benefits, as UCO is processed into biodiesel meeting global standards. This aligns with the concept of resource regeneration in the circular economy, where reuse reduces the need for new resources while creating sustainable economic value.

Furthermore, UCO management within the circular economy framework supports environmental sustainability, particularly in reducing carbon emissions, as biodiesel derived from UCO has a lower carbon footprint than fossil fuels. Thus, UCO management in a circular economy model offers not only economic benefits but also contributes to environmental sustainability goals by promoting renewable energy use and reducing greenhouse gas emissions (Geissdoerfer et al., 2017).

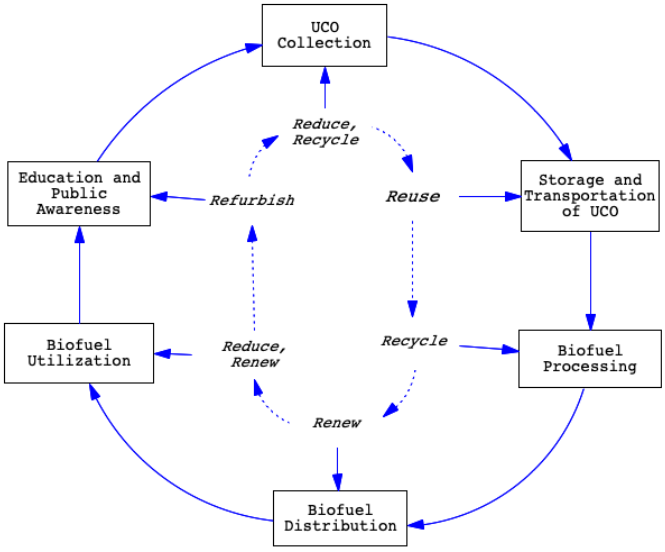

Figure 1: Circular Economy Approach in UCO Management
Source: Processed Data (2024)

As shown in Figure 1, implementing the circular economy in UCO management for biofuel involves several stages, from collection to biofuel usage. Each stage applies principles such as Reduce, Reuse, Recycle, Refurbish, and Renew, all of which contribute to creating a more sustainable and efficient system.

In the initial stage of UCO collection, the concepts of Reduce and Recycle are implemented to minimize the disposal of used cooking oil into the environment. Oil generated from households

and businesses is collected for recycling, instead of being discarded improperly. This reduction in waste mitigates the risks of water and soil pollution, a common issue resulting from the improper disposal of used cooking oil. Through Recycling, UCO, once regarded merely as waste, is transformed into a valuable resource that can be reused in biofuel production (Ellen MacArthur Foundation, 2013).

During the storage and transportation phase, the collected UCO is temporarily stored before being transferred to processing facilities. The principle of Reuse is applied here, as the collected oil will be repurposed as raw material for biodiesel. This process prevents the wastage of new resources and, by treating UCO as a reusable asset, reflects a circular economy that emphasizes sustainable use of materials (Stahel, 2016).

The biofuel processing stage, where UCO is converted into biodiesel through processes like transesterification, embodies the Recycle principle. This recycling process transforms oil, which is no longer suitable for cooking, into biodiesel—a renewable fuel that can serve as an alternative to fossil fuels. Additionally, by-products such as glycerol generated during this process can be utilized in other industrial applications, maximizing the use of all components of the raw material (Geissdoerfer et al., 2017).

In the biofuel distribution phase, the Renew principle becomes predominant. Biofuel produced from UCO is renewable energy, replacing non-renewable fossil fuels and reducing carbon emissions. The distribution of biofuel from renewable sources supports the transition towards a low-carbon economy, contributing to climate change mitigation efforts. During the biofuel utilization stage, both Reduce and Renew concepts are again applied. Biofuel derived from UCO not only decreases carbon emissions from vehicles or machinery using it but also substitutes the consumption of fossil energy. This aligns with the sustainability goals of the circular economy, where the use of renewable energy is prioritized to reduce the global carbon footprint and prolong resource life.

The education and public awareness phase applies the concept of Refurbish, not in the context of physical materials, but rather in altering societal perceptions and attitudes towards UCO waste. Through education programs and awareness campaigns, the public's understanding of how UCO can be used as a valuable resource is refreshed. This mental transformation encourages broader participation in sustainable waste management systems.

The collection of UCO has proven to open new business opportunities, particularly within the circular economy context. Previously regarded as waste, UCO now possesses economic value as a raw material for biofuel production. This collection process involves various economic actors, from households and restaurants to collectors, all benefiting economically from this system.

With the provision of incentives for UCO collection, communities can exchange their used oil for money or goods through waste banks or collectors. Intermediaries such as collectors also earn income by selling UCO to biofuel processing plants. This creates a chain of economic activities engaging multiple stakeholders, including collectors, distributors, and exporters. As demand for biofuel in international markets grows, UCO has become a high-value commodity, offering broader business opportunities for those involved in this supply chain.

Economic Aspect Analysis

In the business process of UCO management for biofuel production, the price of UCO increases at each stage of the supply chain due to value addition through consolidation, quality improvement, and processing. The first stage involves households, restaurants, and small-medium enterprises (SMEs). At this point, UCO is viewed as waste and usually sold at a low price, ranging

from IDR 1,000 to IDR 3,000 per liter. Restaurants and SMEs that produce larger volumes can sell UCO at higher prices, approximately IDR 4,000 to IDR 5,000 per liter.

Subsequently, UCO is typically collected by waste banks, which act as intermediaries between the community and the collectors. Waste banks buy the oil from the community and sell it to collectors at a higher price, around IDR 5,000 to IDR 6,000 per liter. Waste banks enhance UCO's value by ensuring that the oil collected is clean and free from contamination, making it more valuable in the next market phase.

Local collectors then purchase the oil from waste banks, restaurants, or large households. They consolidate the oil in large quantities for sale to aggregators or exporters. At this stage, UCO prices range from IDR 5,500 to IDR 7,500 per liter, and collectors often filter and clean the oil to enhance its quality and value. Aggregators or large-scale collectors are the next actors in the supply chain. They buy UCO in bulk from local collectors, preparing it for export or sale to biofuel producers. Here, the price of UCO can reach IDR 7,500 to IDR 8,500 per liter, depending on the quality and volume available.

Exporters form the subsequent phase, purchasing oil from aggregators and preparing it for export to international markets. UCO is often exported to countries with stringent renewable energy regulations, such as those in Europe, where it is used as a biofuel feedstock. The price at the export stage can rise to IDR 8,000 to IDR 10,000 per liter, influenced by global market demand and transportation costs. The final stage involves biofuel production, where UCO is processed into biodiesel through transesterification. Biofuel producers usually buy UCO at a price of around IDR 8,000 to IDR 12,000 per liter, depending on the quality and purchasing location. The selling price of the produced biodiesel is then determined by market conditions and government policies, such as the B30 biodiesel blending mandate in Indonesia.

Overall, the price increase at each stage of the UCO supply chain reflects value addition through consolidation, purification, and processing into biofuel. In addition to its environmental benefits, UCO management opens economic opportunities within the community, from households and SMEs to large industries. Government incentives and international market demand for biofuel feedstocks further influence the price and sustainability of UCO management processes.

Policy Aspect Analysis

To enhance the implementation of the circular economy in UCO management and ensure its sustainability, several policies and initiatives must be carried out in an integrated and continuous manner. A primary strategy involves strengthening regulations governing UCO management, from collection and processing to its utilization as a biofuel feedstock. The government can implement policies requiring restaurants, hotels, and households to manage their UCO separately and collaborate with waste banks or other collection institutions. Additionally, regulations on the quality standards for UCO that can be used as biofuel feedstocks need to be tightened to ensure the recycled oil is safe and of high quality.

From a regulatory perspective, the government also plays a vital role in facilitating and supporting UCO management. Appropriate regulations can promote investment in UCO collection and processing infrastructure while offering economic incentives to businesses and community members involved. On the other hand, strict enforcement of penalties for illegal UCO disposal can bolster compliance and encourage more responsible practices (Wang et al., 2019).

Increased awareness and community participation are critical factors in a circular economy. Massive educational campaigns should be launched to inform the public about the hazards of reusing UCO as cooking oil and its benefits when processed into biofuel. Community involvement in UCO collection can be bolstered through incentive programs, such as compensation or reward

points for households and SMEs actively donating or selling their UCO. This step aligns with the circular economy's emphasis on waste reduction, reprocessing, and resource reuse (Geissdoerfer et al., 2017).

Moreover, collaboration between the government, the private sector, and civil society is essential in developing UCO management infrastructure. The government can partner with businesses like collectors and biofuel producers to build effective UCO collection and processing facilities. Investing in efficient and environmentally friendly UCO processing technology is also crucial for ensuring long-term sustainability. According to the Ellen MacArthur Foundation (2013), one of the circular economy's main pillars is innovation in technology and processes that enable optimal and sustainable resource utilization.

By implementing circular economy principles at each stage of UCO management, this system focuses not only on waste reduction but also on creating new value from previously useless materials. This approach supports global goals for achieving better environmental and economic sustainability. Overall, UCO management is a concrete example of circular economy application, where waste is transformed into a valuable resource, supporting community economic welfare and environmental sustainability.

CONCLUSION

The management of used cooking oil (UCO) within the circular economy framework offers various benefits, both environmental and social. This process transforms waste into a valuable resource, aligning with the principles of reduction, reuse, recycling, refurbishing, and renewal. By implementing an efficient system for the collection, storage, processing, and conversion of UCO into biofuel, it is possible to minimize waste, reduce environmental pollution, and create economic opportunities throughout the supply chain.

The involvement of multiple actors, including households, waste banks, collectors, exporters, and biofuel producers, illustrates the potential for collaborative efforts in waste management. When managed effectively, this approach not only promotes environmental sustainability but also fosters active community awareness and participation, ultimately contributing to a healthier environment and economic growth.

In conclusion, adopting a circular economy model in UCO management can facilitate the transition to renewable energy sources, lower carbon emissions, and unlock new economic opportunities. This process directly supports local economies while advancing broader sustainability goals. To maximize these benefits, it is crucial to integrate educational initiatives, supportive policies, and technological innovation into this management system.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. organizational behavior and human decision processes, 50(2), 179-211.

Ardila, H., & Halim, R. (2021). managing household cooking oil waste in Indonesia: opportunities and challenges. *Journal of Environmental Management*, 252, 109-119.

Cheng, Y., Zhou, J., Wang, R., & Yin, C. (2020). Environmental impacts of used cooking oil as biodiesel feedstock. *Sustainability*, 12(14), 5705.

Ellen MacArthur Foundation. (2013). *Towards the circular economy: economic and business rationale for an accelerated transition*.

European Commission. (2020). *Circular economy action plan.* Retrieved from https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en.

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy – a new sustainability paradigm? *Journal of Cleaner Production*, 143, 757-768.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11-32. https://doi.org/10.1016/j.jclepro.2015.09.007.

GreenBiz. (2013). $700 Billion in savings: the economics of a circular economy. Retrieved from https://www.greenbiz.com/.

International Council on Clean Transportation (ICCT). (2021). potential economic, health, and greenhouse gas benefits of incorporating used cooking oil into Indonesia's biodiesel program.

Liao, X., Ma, Y., Zhao, M., & Zou, J. (2019). Risks and regulations of reusing waste cooking oil. *Food Control*, 99, 98-104.

Mansor, N. A., & Khamis, M. M. (2022). Waste cooking oil management: policies, public awareness, and practices. Renewable Energy Policy Review, 11(1), 56-67.

Nasution, A., Sihombing, F., & Tarigan, Z. (2018). Opportunities and challenges in waste cooking oil utilization. *Journal of Clean Energy*, 6(2), 89-98.

Recycling International. (2013). Circular economy offers huge potential for savings. Retrieved from https://www.recyclinginternational.com/.

Stahel, W. R. (2016). The circular economy. *Nature*, 531(7595), 435-438.

Wang, L., Liu, H., & Zhang, Z. (2019). From waste to energy: used cooking oil for biodiesel production. *Energy and Environmental Science*, 12(4), 1257-1264.