Malaysian Journal of Social Sciences and Humanities (MJSSH) (e-ISSN : 2504-8562)
2024, Volume 9, Issue 7, e002902
DOI: https://doi.org/10.47405/mjssh.v9i7.2902

RESEARCH ARTICLE

Using Mental Modeling to Study the Management of Used Cooking Oil in Kuala Nerus

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KEYWORDS:
Used cooking oil
Sustainability
Mental model
Knowledge and awareness

CITATION:
Siti Syazuwahanna Mohd Zamri et al. (2024). Using Mental Modeling to Study the Management of Used Cooking Oil in Kuala Nerus. *Malaysian Journal of Social Sciences and Humanities (MJSSH), 9*(7), e002902. https://doi.org/10.47405/mjssh.v9i7.2902

ABSTRACT

Recycling of used cooking oil is an effort by collecting, processing and reusing solid waste or materials that have been used for the purpose of environmental conservation. This study was conducted to identify the level of knowledge and awareness of used cooking oil management among the community in the Kuala Nerus district, Terengganu. The study involved 30 respondents in the community, namely traders, used cooking oil wholesalers, households, students and the government. The study used a mixed method, i.e. qualitative and quantitative research using fuzzy cognitive modelling including individual mental model modeling. The results of the study showed that the knowledge of cooking oil waste recycling among the respondents was still at a moderate level. The results of the study found that for the aspect of qualitative analysis, there were four themes that emerged, namely knowledge, awareness, attitude and culture. While descriptive analysis identifies the most dominant relationship strength is the theme of awareness. The recommendations in this study are necessary to improve the management of used cooking oil in Kuala Nerus through a comprehensive and integrated approach. This study proposes a legal approach, encourages the expansion of this study to a higher level and improves the provision of used cooking oil management infrastructure.

Contribution/Originality: This mental model study contributes to the development of deeper fundamental social science principles regarding the networks and interactions of actors involved and the issues that arise in the waste oil waste management system.

1. Introduction

The use of cooking oil in cooking has become an obligation in all communities around the world (Ahmed & Hossain, 2020). Cooking oil is one of the most important components of daily life and is used for various cooking purposes in home kitchens and in the food industry. The amount of cooking oil used in cooking varies. In Malaysia, cooking oil is widely used in most local communities, especially in food businesses (Pratama et al., 2021). However, if not properly managed, the reuse of cooking oil can lead to health and environmental issues (Khalil et al., 2023). Malaysia is no exception, with Malaysia's Environmental Performance Index (EPI) ranking 130th out of 180 countries (Ahmad, 2022). This indicates that Malaysia has been included in the list of the dirtiest countries in the world.

This study focused on the knowledge and awareness related to cooking oil waste management in Kuala Nerus, Terengganu. Dealing with waste cooking oil involves multiple aspects, including proper collection, storage, and disposal. Failure to systematically collect waste cooking oil can lead to environmental pollution, especially water pollution if the oil is discharged into sewage systems or rivers. This occurs when waste oil is discharged directly into sewage systems or drains, causing blockage of the channels (Chen et al., 2021).

Recycling used cooking oil is an important process to reduce environmental pollution and promote sustainable development (Merman et al., 2023). Used cooking oil is often dumped into waterways or underground, which can cause water and soil pollution and affect ecosystems. Recycling used cooking oil provides a more environmentally friendly alternative and brings significant economic benefits. Used cooking oil can be recycled to produce a variety of useful products, such as biodiesel, soaps, and detergents (Mannu et al., 2020). For example, biodiesel is a renewable fuel that is cleaner than traditional diesel. It reduces emissions of greenhouse gases and other pollutants, thereby helping to combat climate change.

In this study, the researchers focused on the environmental pollution caused by the disposal of waste cooking oil by business activities and synthesized the knowledge and awareness level of waste cooking oil recycling practices among vendors, households and other communities, students and used cooking oil wholesalers. Pollution of Sungai Kim Kim has affected the well-being of residents around Pasir Gudang, Johor, and even caused residents to be admitted to the Intensive Care Unit (ICU) (Yap et al., 2019). The materialistic attitude of some people also causes problems for the environment by dumping waste cooking oil into sewage and sewer systems (Matusineca et al., 2020). It is well known that the used cooking oil residue does not dissolve and gets stuck in the sewers, causing unpleasant odors and blockages. This pollution affects human well-being and soil surface degradation (Munir et al., 2023). According to a comprehensive study, the simple practices of some traders are due to the failure of the responsible person to provide cooking oil waste collection containers (De Feo et al., 2020).

Used cooking oil contains carcinogens and can be harmful to human health if reused (Iqbal et al., 2021). Residual toxins accumulated in used cooking oil, such as polymers, peroxides, aldehydes, amines, or diamines, react in the human body. This can lead to cancer, hypertension, arteriosclerosis, etc. (Ronitawati et al., 2020).

1.1. Research Objectives

Therefore, the purpose of this study was to examine the level of knowledge and awareness regarding environmental sustainability of waste cooking oil recycling. The 3 main objectives were to:

i. To identify the themes that arise in the used cooking oil management system.
ii. To study the strength of the relationship that exists between the three variables in the used cooking oil management system.
iii. To develop a mental model modeling framework for used cooking oil management systems.

2. Literature Review

2.1. Disposal of used cooking oil

This study focuses on the knowledge and awareness related to waste cooking oil disposal in Kuala Neerus, Terengganu. Kuala Neerus is a rapidly developing area on the east coast of Peninsular Malaysia. This may lead to rapid growth in the residential and commercial sectors, including an increase in the number of restaurants and food outlets. This growth is in line with the increase in the use of cooking oil, which poses a challenge to the disposal of waste cooking oil waste. When solid waste increases, problems related to the waste disposal of cooking oil waste arise. Waste disposal of used cooking oil is a major problem in the community, especially in urban areas. Urban areas are areas with concentrated populations and various industrial, administrative and educational activities, where the waste disposal problem of used cooking oil is the most serious. According to Hoque and Rahman (2020), the amount of solid waste generated is equal to the total population of an area. Therefore, the increase in population, improved socioeconomic status and lifestyle and the subsequent increase in household, commercial and factory waste are one of the main factors that lead to the increase in solid waste. To solve this solid waste problem, the government needs to allocate a large budget because the cost of solid waste management from collection, collection, transportation to waste disposal is very high (Shadzili & Sharuddin, 2020).

2.2. Entrepreneurial activity model of edible oil processing enterprises

Food venues include cafeterias and restaurants, which are one of the major causes of river pollution (Abd Rahman et al., 2017). Large-scale open venues, especially in densely populated areas, generate large amounts of solid waste (Helelo et al., 2019). Almost all operations at food industry sites generate waste because not all raw materials are fully used for cooking and not all products are fully used by consumers. According to Khalil et al. (2023), Malaysians produce about 37,390 tons per day, at least 1.17 (kg) per person, and it is expected to double every year. Food waste and used cooking oil are not only generated during food preparation and cooking, but also when cleaning food waste from plates and bowls. Dishwater used to clean kitchen and tableware produces a lot of grease and oil in the dishwater, which then flows into nearby drains. This was confirmed by a previous study by Orjuela and Clark (2020), which found that used cooking oil was the main source of lipids. Therefore, as a solution, the researchers suggested introducing a program for 10 green entrepreneurs to manage the collection of cooking oil waste by converting it into biodiesel (Tesprasit et al., 2020).

2.3. Sustainable edible oil management using the 5R conceptual approach

Used cooking oil can be used to make other ingredients (Foo et al., 2022). This was confirmed by a study conducted in Brazil, where the city of Belo Horizonte has been converting used cooking oil into scented soap bars for cleaning and disinfection since November 2020 (Noronha, 2022). A study by Azme et al. (2023) reported that soap was made from excess cooking oil in an innovative way that could solve the problem of used cooking oil disposal. Converting waste cooking oil into biodiesel is considered a good way to address food security, energy disasters, and environmental issues (Zhao et al., 2020). Previous studies also support the conversion of waste cooking oil into biodiesel as it is more profitable, easier to handle, and ensures a stable supply (Malik et al., 2021).

Recycling also means collecting old materials from old waste and then converting them into a form that is conducive to recycling waste (Khalil et al., 2023). However, these issues can be addressed by individuals and communities to achieve a waste-free nation. Solid waste is considered to be a source or representative of today's society, which is less efficient in waste prevention (Farid et al., 2021). In short, today's society is more aware of systematic waste management by supporting various waste prevention initiatives.

2.4. Study of mental models for the issue of used cooking oil management

2.4.1. Study of Applied Cooking Oil Mental Models for Global Issues

Used cooking oil is categorized as domestic solid waste. The management of used cooking oil (WCO) globally requires a holistic approach that combines public awareness, collection infrastructure, processing technology, and reuse in valuable products such as biodiesel and biolubricant (Yang & Shan, 2021). The mental model helps visualize the flow of the process from source to final product, including logistics issues and market acceptance. Effective measures involve community education, preparation of collection containers, specialized transportation, as well as investment in green technologies. This approach not only reduces environmental pollution but also promotes a sustainable economy. The use of WCO for biodiesel can reduce greenhouse gas emissions and dependence on fossil fuels (Guo et al., 2023; Atabani et al., 2012). Cooking oil waste management is an important, widely addressed global issue. The study highlights the environmental and economic challenges posed by improper disposal of WCOs, which can lead to significant negative impacts. However, WCO can be transformed into a valuable resource, contributing to sustainable practices and circular economy initiatives. A past study has emphasized the importance of recycling WCO to produce biodiesel, biolubricants, and biosurfactants (Manikandan et al., 2023).

2.4.2. Study of the Mental Model of Used Cooking Oil for Malaysian Issues

In Malaysia, the problem of managing used cooking oil is an issue that is getting more and more attention. Used cooking oil is a growing solid waste in Malaysia, causing various environmental and economic challenges. Improper disposal of WCO can cause water and soil pollution and affect human health (Shamsuddin & Zulkifli, 2023). The management of used cooking oil (WCO) in Malaysia requires a comprehensive approach using a mental model involving public awareness, orderly collection, processing technology, and reuse as a valuable product such as biodiesel. Mental models help map the process from source to final product, identifying issues such as lack of public

awareness and inadequate collection infrastructure (Broek et al., 2021). Important measures including ongoing education on the importance of WCO management, the provision of special bins for collection, efficient transportation, and investment in green technologies can be seen in Figure 1. This approach can not only reduce environmental pollution but also support a sustainable economy through green products that can reduce greenhouse gas emissions and dependence on fossil fuels (Wang & Azam, 2024). This study can conclude that this effort can increase public awareness and efficiency of WCO management in Malaysia.

Figure 1: Collection of Used Cooking Oil Waste in the Study Area

 collect cooking oil in a barrel	 collection of used cooking oil for sale	 used cooking oil weighing process

3. Research Methods

This study was conducted in the Kuala Nerus district as shown in Figure 2. Kuala Nerus is a district located in Terengganu with a longitude of 103° 06' E and a latitude of 5° 23' N at the study site (Moslim et al., 2021).

Figure 2: The location of Kuala Terengganu

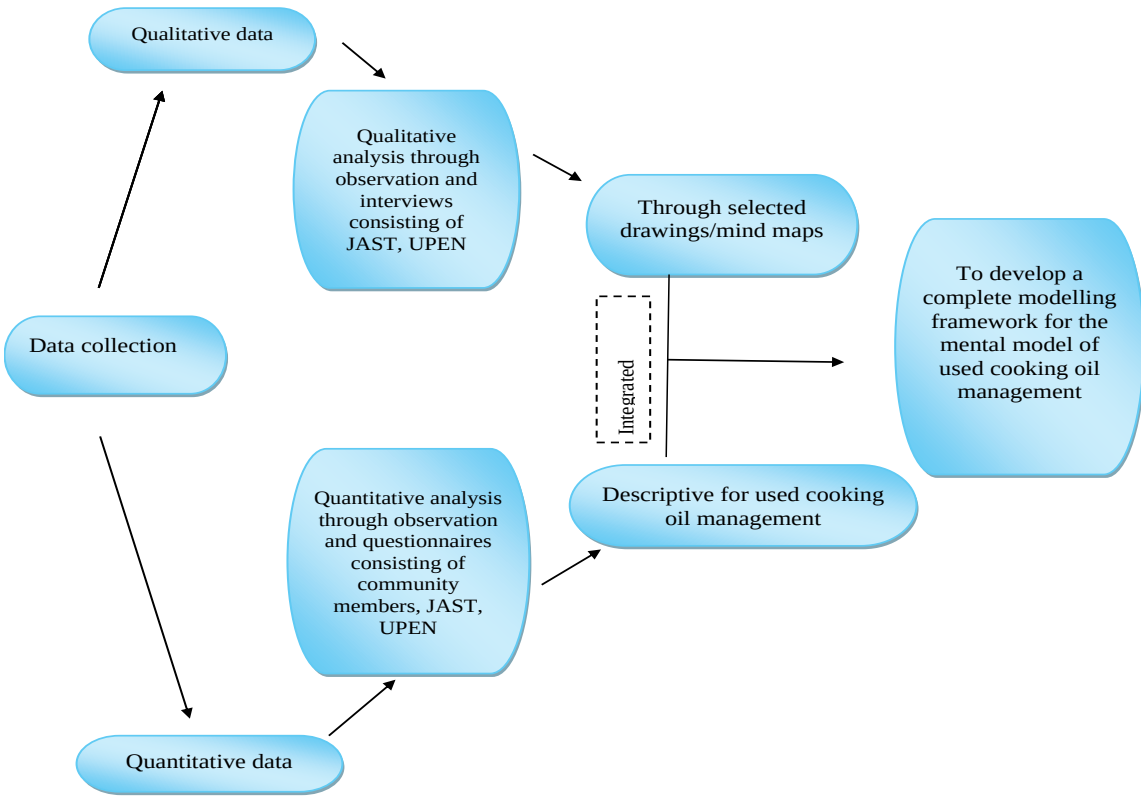
Source: Google Maps (2024)

Meanwhile, this study is a mixed method, namely quantitative and qualitative, involving a total of 30 community respondents consisting of food traders, used cooking oil buyers, students, households and the Terengganu Department of Environment (JAST).

Population refers to a group of individuals, objects, or events that have the same characteristics and need to be studied. The researcher selects the population for the study this is from community and stakeholders in the Kuala Nerus Terengganu. Respondents will be selected through simple random sampling. Technique the data collection used by the researcher is based on primary data and secondary. Primary data includes the results of the distribution of questionnaire scripts using mental model approach, while secondary data is obtained through public documents such as archives, journals, articles, magazines, newspapers, official websites, etc.

The study flowchart is presented in Figure 3 which discusses the framework for data collection and analysis from field observations, questionnaires, and interviews with authorities such as the Department of Environment (DOE) and the National Solid Waste Management Unit (UPEN) and the local community. The data obtained in this study are divided into two, namely primary data and secondary data. The primary data obtained from this method were then analysed using appropriate descriptive techniques to explain and elaborate the dominant relationship between domestic solid waste management systems and residents' awareness and attitude towards recycling. As a result, data is collected using *Mental Model software*. Data obtained from interviews and questionnaires found that the results of used cooking oil management were analyzed based on 4 themes, namely knowledge, awareness, attitude and culture of used cooking oil waste management.

Figure 3: Mental Model Modeling Flow Chart for Used Cooking Oil Waste Management System

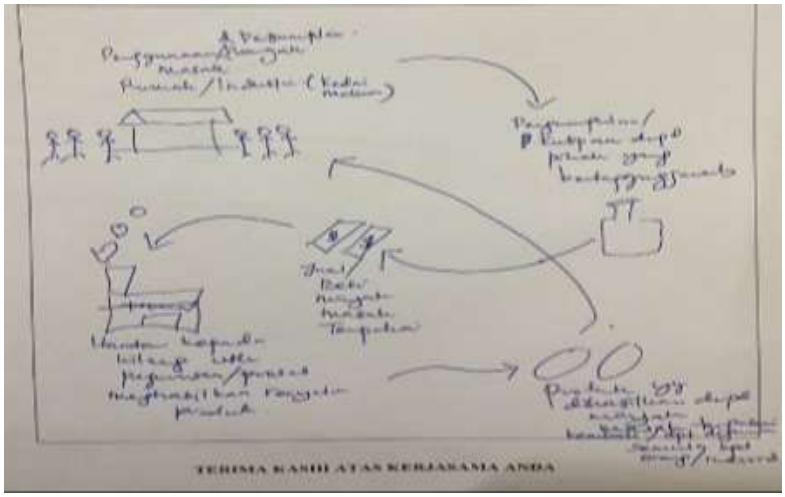
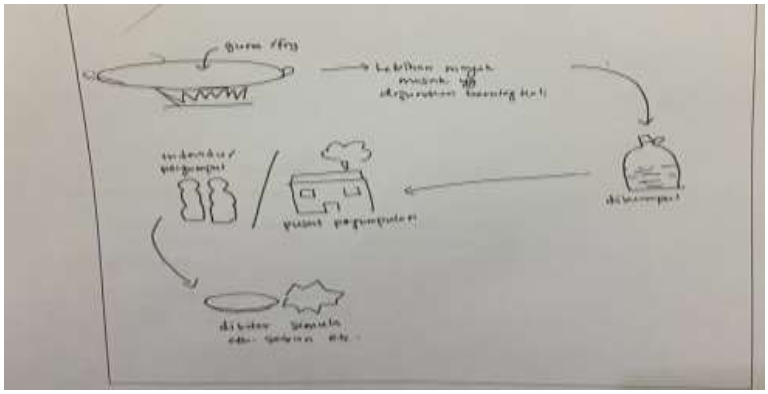


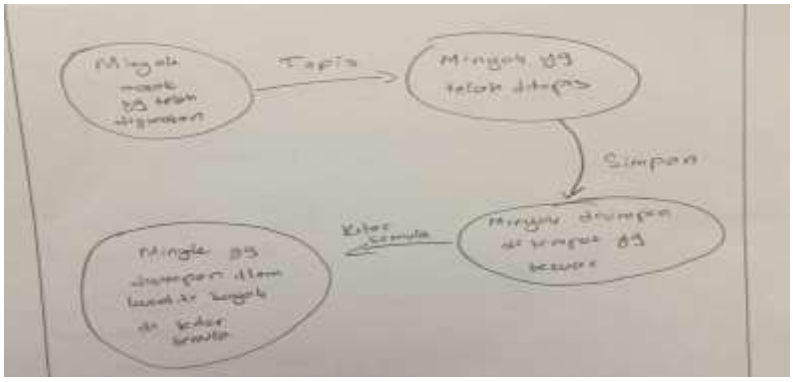
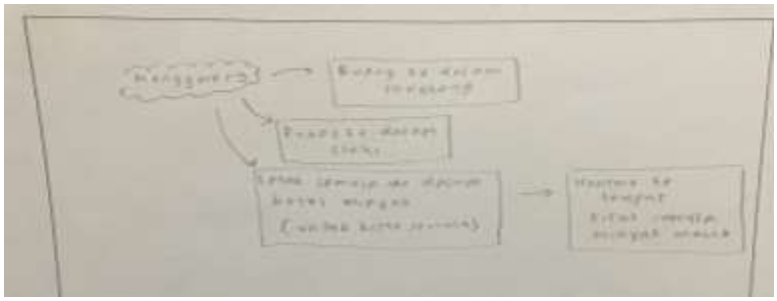
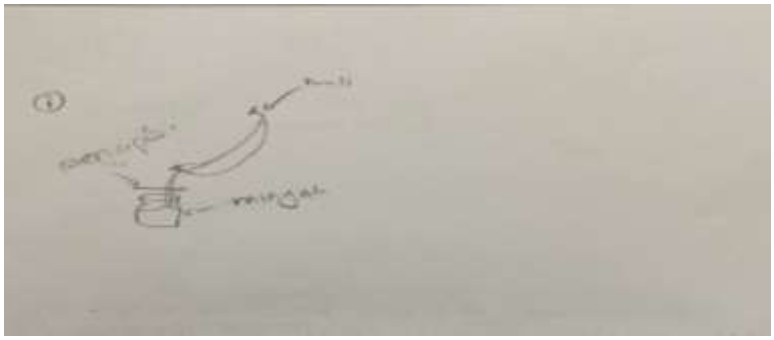
4. Results and Discussion

4.1. Qualitative analysis through sketches of selected paintings

The results of the study will be presented according to the three objectives in the findings of the study which have been detailed in part one. Based on objective one, it has been fulfilled with social analysis carried out through selected sketches where it can help visualize the process of managing used cooking oil more clearly, i.e. the emerging themes have been identified and presented in Table 1. This sketch can also show the positive impact of used cooking oil management on the environment and human health, as well as the importance of providing effective inhalation programmes for public awareness.

Table 1: Analysis Theme

Theme	Information	Sketch/ Mind map of respondents' understanding
Knowledge	Knowing through the mass media. Environmental Education (intermediate level). Have existing knowledge. Not knowing about the recycling of used oil is only a minority.	
How to dispose of	Throw it in the trash. Dispose of it in the sink. Throw it on the ground. Dispose of in the drain. Recycling	

Awareness	Collect for recycling. Disseminate knowledge about used oil recycling.	
Culture	Less practiced	
Attitude	Less aware Slow to act	

4.4.1. Knowledge of Used Cooking Oil Management System

Through the findings of the interviews, most of the respondents are already aware of the existence of oil recycling. Some of the respondents obtained information sources on the recycling of cooking oil waste through the internet and other mass media such as television, posters and newspapers. Disclosure of information on the recycling of used oil is limited compared to other domestic wastes such as glass, paper and cans. Such knowledge is rarely exposed to rural communities and rural areas, causing it to be limited to the intelligent, and in turn, causing awareness of the environment to be incomplete and does not include urban and rural residents. Therefore, efforts need to be further expanded, especially through media that have an extensive information network such as print and television so that all levels of society are exposed to the knowledge of recycling cooking oil waste.

4.4.2. How to Dispose of Used Oil

Data from the study on the frequency of use of used cooking oil showed that 86.7% or 26 of the respondents used cooking oil more than three times before the oil was disposed of or thrown away. There were also respondents who admitted to using the oil repeatedly until it turned black. The use of cooking oil more than twice and repeatedly can be

harmful and have toxic effects on health (Sari et al., 2022). This scenario of repeated use of cooking oil has become a habit for a few households and traders in the country, finding that although the majority of traders know that repeated use of cooking oil is not good for health, they still use the oil.

In this study, the used cooking oil generated in each activity was disposed of through various means such as being thrown into the ground, sinks, trash cans and drains. It was found that only a minority, namely 3 respondents, practised the practice of recycling cooking oil waste by collecting oil waste while the others would dispose of it directly into the drainage.

> *"My aunt will always collect a lot of leftover cooking oil into a big barrel, later it will be very full, my aunt will call people who come to buy oil".*
>
> *(Respondent 15)*

> *"We usually collect this cooking oil in a big barrel, then it will take two or three weeks for oil collectors to come and buy it".*
>
> *(Respondent 16)*

> *"I will collect the used cooking oil in the barrel when I finish frying".*
>
> *(Respondent 17)*

> *"I often throw leftover cooking oil in the sink".*
>
> *(Respondent 18)*

> *"Previously, I only threw used oil into the sink and ran hot water afterwards".*
>
> *(Respondent 24)*

4.4.3. Environmental Awareness.

The exposure on the recycling of used cooking oil through the mass media and the official website of JAST has to some extent raised awareness of protecting the environment and subsequently strengthened the enthusiasm and motivation to practice recycling used cooking oil. The results of the interviews showed that the respondents were very committed to recycling used cooking oil and would disseminate information on the recycling of used cooking oil to students, friends and family.

> *"…. if there is an allocation, we will invite Petronas, TNB or other industry parties as strategic companies to carry out sustainability programmes, which we will advertise through Facebook or the official website of the department of environment...."*
>
> *(JAST).*

> *"I collect used cooking oil and put it in a special container". "When there is a lot of it, I will send it to the used cooking oil collection centre so that it can be recycled". "I will also remind my family members of the same thing because the cooperation of many parties will definitely have a positive impact on this issue".*
>
> *(Respondent 24)*

> *"I will invite my family to recycle oil and tell them the danger of our actions to the environment. I will also share my knowledge on oil recycling".*
>
> *(Respondent 28)*

4.4.4. Culture and Attitude of Collecting Used Cooking Oil

These findings are in line with a study by Noor et al. (2023) which discusses in relation to domestic waste segregation where only a minority of households and traders recycle used cooking oil and the rest is disposed of in the environment. Similarly, the findings of a study conducted in Nanjing, China, showed that 90.2% of the restaurants studied disposed of used cooking oil by disposing of the cooking oil waste and only 9.8% chose to recycle cooking oil waste (Zhang et al., 2020). The same findings are shown in the study of Khalil et al. (2023), where the level of cooking oil recycling practices in the community is still at a low level where they prefer to throw oil waste into drains, sinks and toilets. This clearly shows that they do not practice this cooking oil cycle practice in their daily lives. Among the factors is that the busyness of the respondents limits them to collect used cooking oil which is dumped directly into the sink, drain or soil to speed up the process of daily activities.

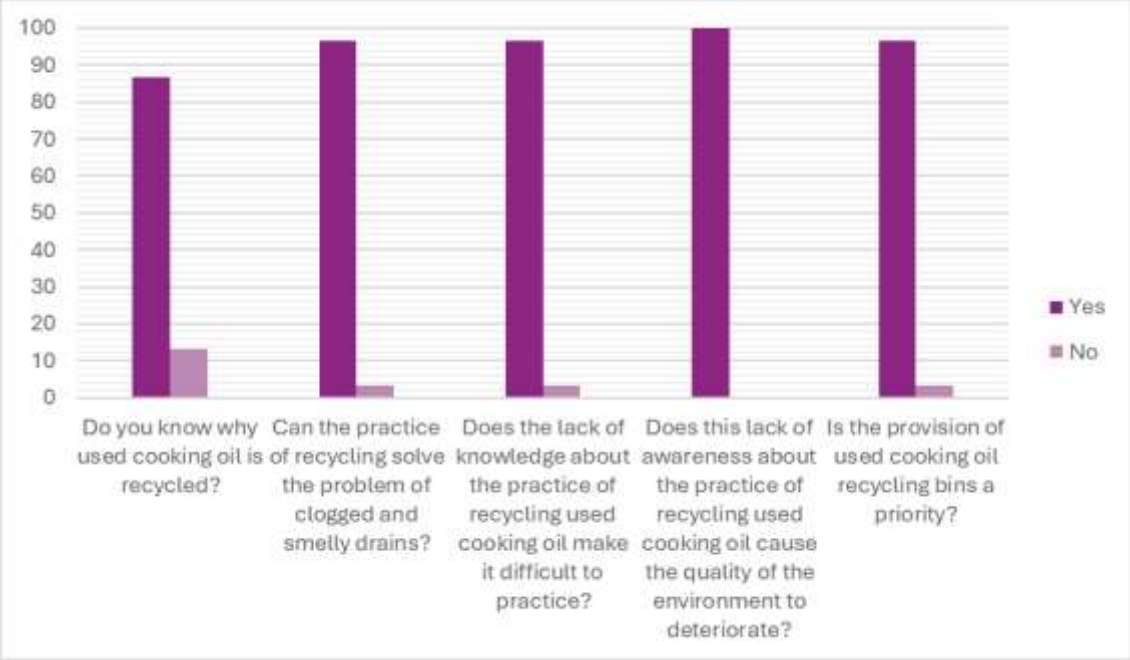
4.2. Descriptive analysis for used cooking oil management

Based on objective two, it is explained that related to the descriptive analysis of used cooking oil management involving factors, impacts and steps on various aspects of used cooking oil management to cultivate the practice. Effective management of used cooking oil not only helps reduce environmental pollution but also contributes to a sustainable economy by turning waste into useful resources. This can be seen in Figure 4, Figure 5, and Figure 6 in relation to the recycling of used cooking oil

4.2.1. Factors of used cooking oil recycling practices

The findings of the study in Figure 4 found that all respondents knew that the lack of awareness of the practice of recycling used cooking oil would have a negative impact on the environment, which is equivalent to 100%. This study is in line with a previous study where it stated that more than 60% of used cooking oil from the domestic sector in Europe is disposed of in an improper way, which causes damage to the sewerage system and increases the cost of water treatment operations by up to 25% (De Feo et al., 2020). Used cooking oil discharged into the sewerage can cause clogging of pipes and disruption to the filter system and oil/water separator in the wastewater treatment plant. Based on the findings of a study from the understanding of the respondents on the recycling factors of used cooking oil, it can be paralleled with a study from Smith and Taylor (2020) showing that the disposal of used cooking oil in landfills can produce methane gas, which is a greenhouse gas that contributes to global warming. The lack of awareness and knowledge on how to recycle used cooking oil results in irresponsible disposal practices that increase the cost of cleanup and pollution management by local authorities (Merman et al., 2023). According to a study by Sultana et al. (2022), the practice of recycling used cooking oil can significantly reduce the formation of fatbergs. This is because the recycled oil will not enter the sewerage system and reduce the risk of clogging and smell pollution.

Figure 4: Used cooking oil recycling factors



Then, the findings of the study found that the respondents' knowledge of the causes of used cooking oil being recycled was low, which was 86.7% equivalent to 26 respondents who knew about the matter. In a study by Universiti Kuala Lumpur (UniKL), Farrina (2023) and her team developed an innovative storage container to facilitate the collection of used cooking oil at home. The study found that the community's awareness of the importance of recycling used cooking oil and the potential for additional income to be generated is still low. They collaborated with SWCorp and Alam Flora to raise this awareness among the population (Farrina, 2023).

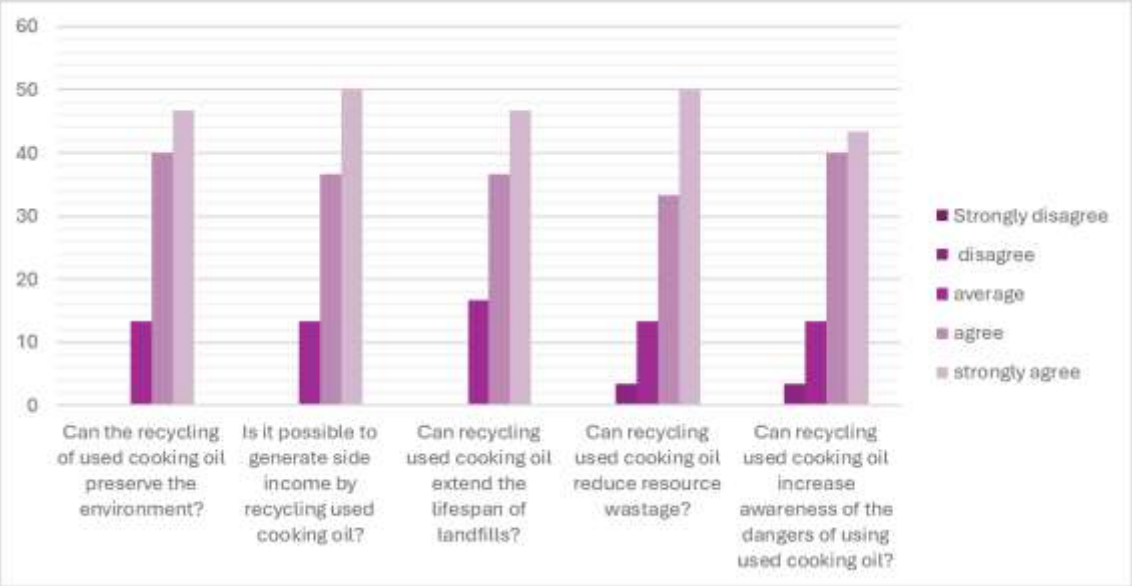
4.2.2. Impact of recycling used cooking oil

Based on Figure 5, the highest number of respondents agreed with the second and fourth impact questions, which was 50% or 15 respondents. The graph above is Figure 5, shows that the theme that arises is the awareness where there is no doubt that used cooking oil can indeed generate side income and reduce the waste of resources. This can be reinforced by the previous article that the recycling of used cooking oil supports the concept of circular economy, where waste is transformed into a useful resource. By recycling used cooking oil, materials that would otherwise be discarded can be transformed into valuable products, such as biodiesel and soap, which reduces the amount of waste that goes into landfills (Ibrahim, 2023).

According to a study made by Chen et al. (2021) shows that by recycling used cooking oil, water and soil pollution can be reduced. Used cooking oil that is disposed of improperly can contaminate water and soil and disrupt ecosystems. According to Merman et al. (2023), education and awareness programs on the dangers of using used cooking oil can increase public understanding of the environmental problems caused. This awareness helps motivate the community to take positive actions such as recycling used cooking oil, reducing the irresponsible disposal of such oil, and supporting more sustainable practices. It can be concluded that recycling used cooking oil not only provides economic benefits but also has a huge positive impact on the environment and human health. This is a holistic approach to reducing pollution, repurposing available

resources, and raising community awareness of their responsibility to the environment.

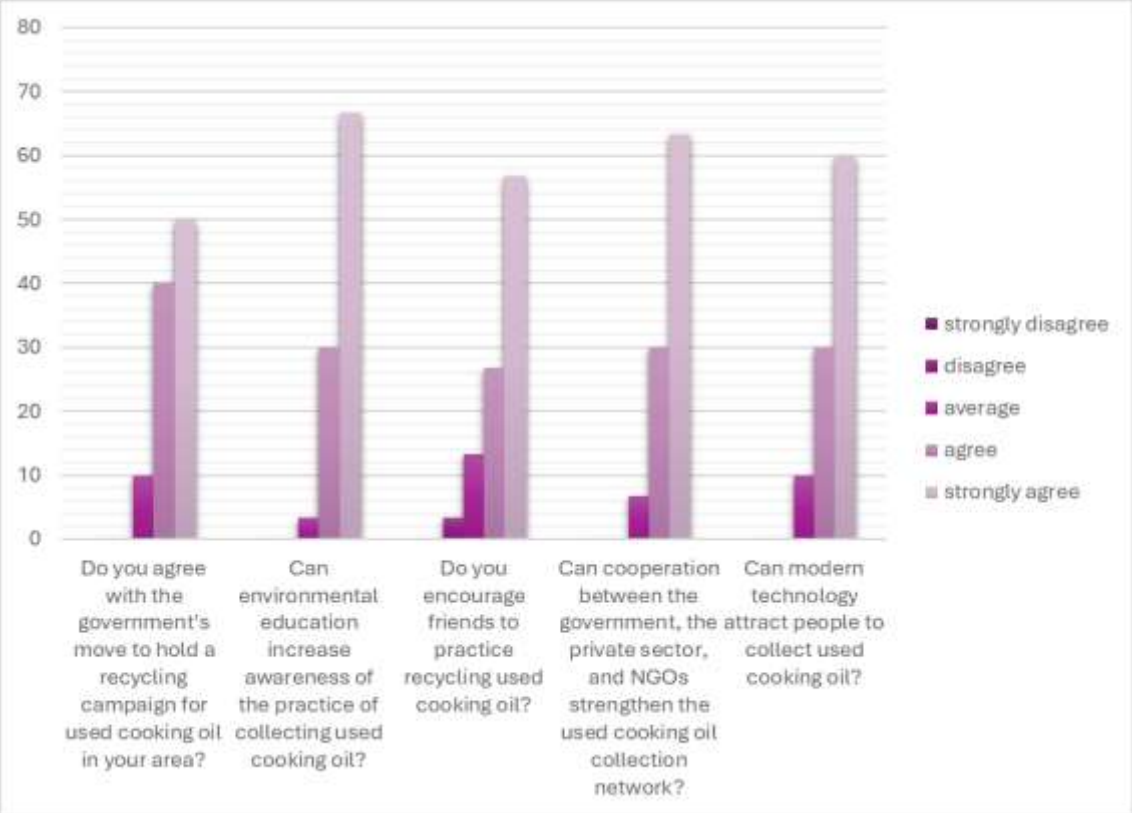
Figure 5: Impact of recycling used cooking oil



4.2.3. Measures to improve the recycling practice of used cooking oil

Based on Figure 6, the largest number of respondents was a very agreeable scale, namely the second step question on environmental education to increase awareness, which was 20 respondents equivalent to 66.7%.

Figure 6: Measures to improve the recycling practice of used cooking oil

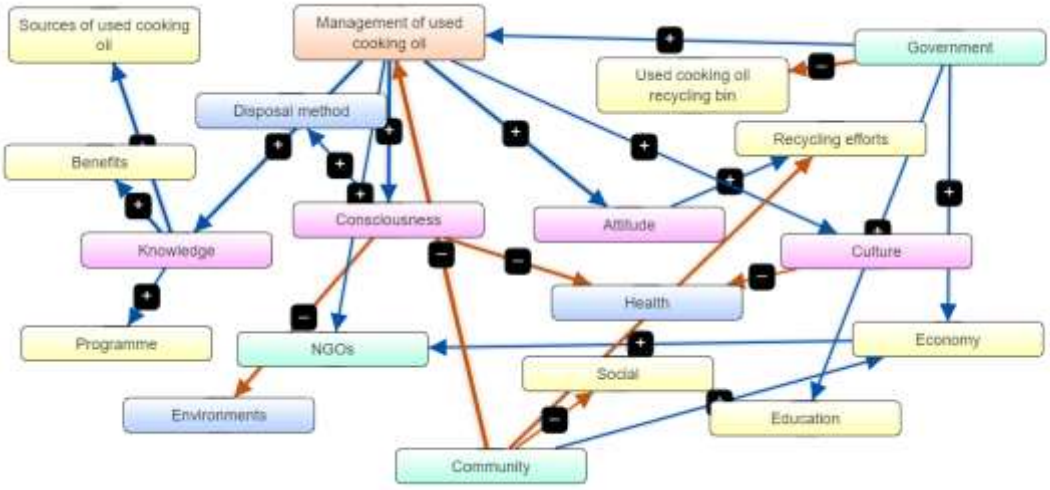


This is because with this environmental education, it can increase awareness of the practice of collecting used cooking oil. This can be proven by a study from Knickmeyer (2020), stating that the element of awareness can influence an individual's knowledge of the expected outcome of waste segregation. A thorough knowledge of the outcome of an action or behavior can shape a person's understanding of the expected outcome (Zhang et al., 2023). Therefore, according to Johnson and Činčera (2023), environmental education is a field of study that aims to promote not only awareness and understanding of the environment, but also the responsibility to improve the quality of life.

4.3. Mental modelling of used cooking oil systems

The findings of the study were obtained based on knowledge and awareness on the recycling of used cooking oil. The themes and subthemes that have been identified using the Mental Model method shown in Figure 7. According to Jones et al. (2011), a mental model is a notion in a student's mind that is used to explain, explain, and anticipate a phenomenon. Based on the Figure 7, it shows that the Mental Model framework has been successfully formed on the concept of used cooking oil waste management based on the knowledge and awareness of the community in the Kuala Nerus district, Terengganu. The Figure 7 above also explains that the blue arrow means that the community has high information abilities about the issues discussed while the orange arrow means that the community has less information abilities about the management of used cooking oil for recycling. The thicker the arrow means that most communities have a high level of information about the concept of used cooking oil management and if thin it is the opposite. The nature of the arrow in Figure 7 also shows the characterization aspect of the Mental Model framework of Kuala Nerus traders, Terengganu regarding the concept of used cooking oil management.

Figure 7: Conceptual Framework of the Mental Model for Waste Used Cooking Oil



Referring to Blacketer et al. (2021), a modularity score based on the configuration of the edge-between algorithm has been used to analyze centrality, density and policy scenarios. To assess the role of each variable in a system, variables are categorized as drivers, receivers, or regulars. Outdegree indicates the cumulative strength of the connection exiting the variable, while indegree indicates the cumulative strength of the variable entering the variable. The driver variable has a positive outer degree and a non-zero degree, the receiver variable has a positive outer degree and a zero outer degree,

and the normal variable has both a non-degree and a non-zero degree. The centrality of each concept in each individual map is calculated as the sum of the outdegree and indegree concepts. This metric serves to understand the main way a concept is viewed in the system. Once all metrics have been calculated for individual models, the metrics are averaged by stakeholder groups and the variance is determined by profession (Table 2).

Table 2: Structural Matrix

Structure Matrix	Model Group
Total Components	19
Total connections	22
Density	0.0643274854 (0.06)
Connections per components	1.1578947368 (1.16)
Number of driver components	2
Number of receiver components	11
Number of ordinary components	6
Complexity score	5.5

Based on Table 2, the model illustrates the structure of a used cooking oil management system that has 19 components with 22 connections. The sum of components refers to all the entities or elements involved in this system. There are 22 connections that represent the relationships and interactions between these components, showing how information or material flows between them. The density of the mesh is 0.0643274854 (0.06), which indicates the ratio between the number of available connections and the maximum possible connections, illustrating that not all components are directly connected. The average number of connections per component is 1.1578947368 (1.16), measuring the average number of connections per component in the system. There are 2 driver components that play a major role in moving or influencing the network, acting as the main source or mover. Meanwhile, the 11 receiver components act as elements that receive inputs or are influenced by other components, acting as reception points in the system flow. In addition, there are 6 common components that do not act as the main driver or receiver but are still involved in the network, perhaps as a link or supporter in the flow of the system. The complexity score for this model is 5.5, which gives an idea of the complexity of the system based on the number of components and the connections and interactions between them. The higher the complexity score, the more complex the network is. This explanation helps to understand the structure and function of each component in the used cooking oil management system analyzed.

4.3.1. Results of MM theme variables

Overall, the results of the mental theme variables of this model provide insight into how each component interacts in a used cooking oil management system and point to the need for improved relationships and cooperation between all parties involved to improve the effectiveness of this system. MM modelling shows the results of the variable mental theme of the model in the management of used cooking oil consisting of the strongest emerging theme from the diagram is the awareness of the management of used cooking oil. Awareness plays an important role because it becomes the main link that influences various other components in the model. This awareness is directly related to knowledge, attitudes, and recycling efforts which are all important in ensuring effective management of used cooking oil. Knowledge raises awareness about the benefits of recycling used cooking oil and proper disposal methods, while a positive

attitude towards recycling encourages individuals to engage in this endeavor. High awareness also influences other components such as health, culture, and the economy in a positive way. For example, increased awareness can lead to more effective programmes and initiatives from NGOs and governments, which in turn can improve the environmental and health aspects of the community. Therefore, awareness is the most powerful theme because it is the main driver that connects and influences many important aspects of the used cooking oil management system, ensuring that each component moves in harmony to achieve the desired purpose.

A weak theme in this mental model is the health component. Although health has some relationship with other components such as awareness, culture, and community, its role in influencing used cooking oil management systems is not as strong. Health in this context is more influenced by other factors such as attitudes and culture, and does not play a major role as a driver in this system. Existing negative relationships indicate the presence of influence but not on a large scale to significantly affect the overall system. This suggests that increased awareness about health can be helpful, but not strong enough to be a major factor driving used cooking oil management systems. This is the case because the health component does not directly and significantly affect the used cooking oil management system. In this model, health is more influenced by consciousness, culture, and community, but it does not play a role as a major driver. Factors such as knowledge of the benefits of recycling, positive attitudes towards recycling, and policies and programs implemented by the government and NGOs are stronger in driving this system. Therefore, while health is an important aspect, in this context, it is not strong enough to be a major factor influencing the effectiveness of the overall used cooking oil management system, compared to other factors that are more direct and actively involved in the recycling process.

4.4. Limitations of further studies and recommendations

However, there are some analytical constraints associated with this used cooking oil management system. The lack of sufficient data leads to less comprehensive analysis. This is because the lack of accurate and detailed data makes it difficult for researchers to fully understand the scale of the problem and the effectiveness of the measures taken, resulting in the results taken based on the studies being less accurate or irrelevant to the actual situation in the field. While limited time limits the data collection and analysis process, reducing the reliability of the results. The mental model used may not be able to cover all important aspects, such as economic factors and government regulations, making it too simplistic. Additionally, the focus of research on only a few themes can lead to incomplete or biased views, which hinders a thorough understanding of possible issues and measures. These limitations should be taken into account for future study improvements.

Based on the limitations identified, several recommendations could be made to improve the study of used cooking oil (WCO) management in Malaysia. First, expanding the network of collaboration between researchers, industry, and stakeholders to improve access to more comprehensive and quality data. Second, more flexible study scheduling to allow for more comprehensive data collection and in-depth analysis. Third, the use of more complex or integrative mental models that can include a wider range of aspects including social, economic, and environmental factors. This is to investigate the strength of more accurate relationships based on quantitative analysis studies at a higher level while qualitative analysis can be used in a variety of ways such as mind maps, drawings

and fuzzy cognitive pomodeling. Lastly, the use of a study methodology that allows for multi-disciplinary and holistic research to better understand the complex interactions in WCO management in Malaysia. By doing this, it is hoped that the study will provide deeper insights and more effective solutions in overcoming WCO management challenges.

5. Conclusion and policy recommendations

To improve the management of used cooking oil (WCO) in Malaysia, the conclusion that can be drawn is the need for reform and enforcement of relevant policies and laws to ensure industry compliance with effective practices in the collection, transportation, and processing of WCOs. For example, making it mandatory for all restaurants and food factories to store and deliver WCO to processing centers on a regular basis. In addition, the importance of continuous implementation of public awareness campaigns to increase public understanding of the importance of WCO management for the environment and the economy. Close cooperation with authorities such as the Department of Environment Malaysia needs to be enhanced to ensure effective monitoring and supervision of the implementation of best practices in the industry. Investing in the development of the right infrastructure is also important to facilitate the efficient and effective collection and processing of WCOs such as easily accessible collection containers and well-organized transportation systems. This can help speed up the flow of WCO from source to processing more efficiently. By taking these steps, it is hoped that the management of WCO in Malaysia can be improved more effectively and effectively in the long term.

Using Mental Modeler software, it can identify emerging themes in the WCO management system. By applying appropriate mental models, such as those that combine technical, economic, and social aspects, we can identify weak points and opportunities to improve operational efficiency and safety. The mental model also helps in planning more effective strategies in the collection, transport, processing, and reuse of WCOs, as well as in ensuring compliance with safety regulations and standards. Through the use of the right mental model, it is hoped that the management of WCO can be effectively improved, contributing to environmental sustainability and sustainable economic development.

Ethics Approval and Consent to Participate

The researchers used the research ethics guidelines prepared by the Research Ethics Committee of Universiti Malaysia Terengganu (UMT). All procedures performed in this study involving human subjects have been carried out in accordance with the ethical standards of the institution's research committee. Permission and consent to participate in the study were also obtained from all study participants.

Acknowledgement

The researcher would like to express his appreciation to Universiti Malaysia Terengganu, the supervisors and lecturers involved for all the support provided and the respondents who are from the community around Kuala Nerus, Terengganu for their excellent cooperation throughout the study.

Funding

This publication does not receive any sponsorship or financial assistance.

Conflict of Interest

The author has no conflict of interest with any party involved in this study and publication.

References

Abd Rahman, N. S., Zahidi, S. A., Md Zain, S., & Ahmad Basri, N. E. (2017). Pengumpulan Minyak Masak Terpakai dan Pengurusan Sisa Makanan Kafeteria. *Jurnal Kejuruteraan,* 1, 57-62.

Ahmad, A. (2022, Ogos 5). Malaysia ke 130 dalam Indeks Prestasi Alam Sekitar. *Utusan Malaysia*. https://www.utusan.com.my/berita/2022/08/malaysia-ke-130-dalam-indeks-prestasi-alam-sekitar/

Ahmed, R. B., & Hossain, K. (2020). Waste cooking oil as an asphalt rejuvenator: A state-of-the-art review. *Construction and Building Materials*, 230,116-985. https://doi.org/10.1016/j.conbuildmat.2019.116985

Atabani, A. E., Silitonga, A. S., Badruddin, I. A., Mahlia, T. M. I., Masjuki, H., & Mekhilef, S. (2012). A Comprehensive Review on Biodiesel as an Alternative Energy Resource and Its Characteristics. *Renewable and Sustainable Energy Reviews*, *16*(4), 2070-2093. https://doi.org/10.1016/j.rser.2012.01.003

Azme, S. N. K., Yusoff, N. S. I. M., Chin, L. Y., Mohd, Y., Hamid, R. D., Jalil, M. N., ... & Zain, Z. M. (2023). Recycling waste cooking oil into soap: Knowledge transfer through community service learning. *Cleaner Waste Systems*, *4,* 100084. https://doi.org/10.1016/j.clwas.2023.100084

Blacketer, M. P., Brownlee, M. T., Baldwin, E. D., & Bowen, B. B. (2021). Fuzzy cognitive maps of social-ecological complexity: applying mental modeler to the Bonneville salt flats. *Ecological Complexity*, 47, 100950. https://doi.org/10.1016/j.ecocom.2021.100950

Broek, K., Luomba, J., Broek, J., & Fischer, H. (2021). Evaluating the Application of the Mental Model Mapping Tool (M-Tool). *Front. Psychol,* 12, 761882. https://doi.org/10.3389/fpsyg.2021.761882

Chen, C., Chitose, A., Kusadokoro, M., Nie, H., Xu, W., Yang, F., & Yang, S. (2021). Sustainability and challenges in biodiesel production from waste cooking oil: An advanced bibliometric analysis. *Energy Reports*, 7, 4022-4034. https://doi.org/10.1016/j.egyr.2021.06.084

De Feo, G., Di Domenico, A., Ferrara, C., Abate, S., & Sesti Osseo, L. (2020). Evolution of waste cooking oil collection in an area with long-standing waste management problems. *Sustainability*, *12*(20), 8578. https://doi.org/10.3390/su12208578

Farid, N. S. H. M., Ahmad, N., & Seman, N. A. A. Hubungan Di Antara Amalan Pembuatan Mampan Dan Prestasi Mampan Dalam Sektor Pembuatan. I*nternational Journal of Innovation and Industrial Revolution (IJIREV), 3*(8), 10-30. https://doi.org/10.35631/IJIREV.38002

Farrina, Z. (2023, June 25). Unikl Researchers Develop Innovative Container to Encourage Used Oil Recycling. *UniKL Universiti Kuala Lumpur*. https://www.unikl.edu.my/innovativecontaineroilrecycling/

Foo, W.H., Koay, S.S.N., Chia, S.R., Chia, W.Y., Tang, D.Y.Y., Nomanbhay, S., Chew, K.W., (2022). Recent advances in the conversion of waste cooking oil into value-added products: a review. *Fuel*, 324, 124539. https://doi.org/10.1016/j.fuel.2022.124539

Google Maps, (2024, Mac 22). https://www.google.com/maps/place/Kuala+Nerus,+Terengganu [22 Mac 2024].

Guo, M., Song, W., & Buhain, J. (2023). Bioenergy and biofuels: History, status, and perspective. *Renewable and Sustainable Energy Reviews*, *4*(2), 712-725. https://doi.org/10.1016/j.rser.2014.10.013

Helelo, A. B., Senbeta, A. F., & Anshebo, S. T. (2019). Assessment of solid waste management (SWM) practices in Hawassa University campuses, Ethiopia. *Journal of Applied Sciences and Environmental Management*, *23*(6), 1081-1086. https://dx.doi.org/10.4314/jasem.v23i6.13

Hoque, M. M., & Rahman, M. T. U. (2020). Landfill area estimation based on solid waste collection prediction using ANN model and final waste disposal options. *Journal of Cleaner Production*, 256, 120387. https://doi.org/10.1016/j.jclepro.2020.120387

Ibrahim I, M. (2023, Julai 18). Minyak masak terpakai sumber pendapatan tambahan. *Berita Harian.* https://www.bharian.com.my/berita/nasional/2023/07/1128042/minyak-masak-terpakai-sumber-pendapatan-tambahan

Iqbal, N., Sharma, R., Hazra , D. K., Dubey, S., Kumar, N., Agrawal, A., & Kumar, J. (2021). Successful utilization of waste cooking oil in Neem oil based fungicide. *Journal of Cleaner Production,* 288, 125631. https://doi.org/10.1016/j.jclepro.2020.125631

Johnson, B., & Činčera, J. (2023). Relationships between Outdoor Environmental Education Program Characteristics and Children's Environmental Values and Behaviours*. Journal of Adventure Education and Outdoor Learning, 23*(2), 184-201. https://doi.org/10.1080/14729679.2021.2001756

Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental Models: An Interdisciplinary Synthesis of Theory and Methods. *Ecology and Society, 16*(1), 46. https://www.jstor.org/stable/26268859

Khalil, N. A., Ismail, N., & Ariffin, A. (2023). Kajian Tahap Pengetahuan dan Amalan Kitar Semula di Kalangan Warga Politeknik Tuanku Sultanah Bahiyah. *Public Health and Safety International Journal, 3*(1), 21-31. https://doi.org/10.55642/phasij.v3i01.296

Knickmeyer, D. (2020). Social factors influencing household waste separation: A literature review on good practices to improve the recycling performance of urban areas. *Journal of Cleaner Production,* 245, 118605. https://doi.org/10.1016/j.jclepro.2019.118605

Malik, M. S. A., Jaafar, M. N. M., Mavalavan, N., Ismail, M. S. M., Rahim, M. R., & Said, M. (2021). Prestasi Pembakaran Biodiesel Berasaskan Minyak Bunga Matahari Ke Atas Pembakar Berbahan Api Cecair: Combustion Performance Sunflower Oil Biodiesel on Liquid Fuel Burner. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, *82*(2), 127145. https://doi.org/10.37934/arfmts.82.2.127145

Manikandan, G., Kanna, P. R., Taler, D., & Sobota, T. (2023). Review of Waste Cooking Oil (WCO) as a Feedstock for Biofuel—Indian Perspective. *Energies*, 16, 1739. https://doi.org/10.3390/en16041739

Mannu, A., Garroni, S., Ibanez Porras, J., & Mele, A. (2020). Available technologies and materials for waste cooking oil recycling. *Processes*, *8*(3), 366. https://doi.org/10.3390/pr8030366

Matušinec, J., Hrabec, D., Šomplák, R., Nevrlý, V., Pecha, J., Smejkalová, V., & Redutskiy, Y. (2020). Cooking Oil and Fat Waste Management: A Review of The Current

State. *Chemical Engineering Transactions*, 81, 763-768. https://doi.org/10.3303/CET2081128

Merman, H., Tagie, G., W Mohd Apandi, W. N., Ismail, I., & Mohd Jainal, A. (2023). The impact of creative activities involving cooking oil waste on sustainable environments. *Idealogy Journal*, *8*(1), 52-63. https://doi.org/10.24191/idealogy.v8i1.388

Moslim, N., Mokhtar, N., Zubairi, Y., & Hussin, A. (2021). Understanding the Behaviour of Wind Direction in Malaysia during Monsoon Seasons using Replicated Functional Relationship in von Mises Distribution. *Sains Malaysiana, 50*(7), 2035-2045. http://doi.org/10.17576/jsm-2021-5007-18

Munir, M. A., Hussain, A., Farooq, M., Habib, M. S., & Shahzad, M. F. (2023). Data-Driven Transformation: The Role of Ambidexterity and Analytics Capability in Building Dynamic and Sustainable Supply Chains. *Sustainability*, *15*(14), 10896. https://doi.org/10.3390/su151410896

Noor, N. H. M., & Nordin, N. B. (2023). Undang-Undang Dan Dasar Alam Sekitar Terhadap Pengasingan Sisa Domestik: Kajian Kesan Tidak Langsung Kesedaran Masyarakat. *Asian Journal Of Environment, History And Heritage*, *7*(2), *25-39.*

Noronha, P.M. (2022, 30 June). Transforming waste into soap. *Nature*. https://www.nature.com/articles/d41586-022-01817-6

Orjuela, A., & Clark, J. (2020). Green chemicals from used cooking oils: Trends, challenges, and opportunities. *Current opinion in green and sustainable chemistry*, 26, 100369. https://doi.org/10.1016/j.cogsc.2020.100369

Pratama, I., & Ernah, E. (2021). Analisis proses keputusan pembelian minyak goreng sawit: studi kasus pada warga korea di kabupaten bekasi. *Jurnal Ilmu Keluarga & Konsumen*, *14*(2), 176-188. http://dx.doi.org/10.24156/jikk.

Ronitawati, P., Riantama, V., & Palupir, K. C. (2020). Faktor Yang Berhubungan Dengan Penggunaan Minyak Berulang Pada Pelaku Usaha Makanan. *Jurnal Riset Gizi*, *8*(2), 116-121.https://doi.org/10.31983/jrg.v8i2.6357

Sari, S. P., Yuliati, E., Metty, S. D., & Shayida, H. (2022). Gambaran Pola Konsumsi Minyak Goreng Pada Rumah Tangga. *In Prosiding Seminar Nasional Multidisiplin Ilmu, 4*(1), 131-138.

Shadzili, S. B. A., & Sharuddin, P. S. B. (2020). *Kajian Tahap Kesedaran Kakitangan Pengurusan Fasiliti Terhadap Kepentingan Pengurusan E-sisa.* [Ijazah Sarjana Muda Teknologi Pengurusan Fasiliti Dengan Kepujian, Politeknik Sultan Salahuddin Abdul Aziz Shah].

Shamsuddin, N., & Zulkifli, N. (2023*). Eco - Burning Barrels. Politeknik Sultan Salahuddin Abdul Aziz Shah. Various Waste Cooking Oils for Biodiesel Production: A Comprehensive Analysis of Feedstock.* [Diploma Kejuruteraan Awam, Politeknik Sultan Salahuddin Abdul Aziz Shah].

Smith, J., & Taylor, L. (2020). Environmental Benefits of Recycling Used Cooking Oil. *Journal of Environmental Management,* 255, 109-847.

Sultana, N., Roddick, F., Gao, L., Guo, M., & Pramanik, B. K. (2022). Understanding the properties of fat, oil, and grease and their removal using grease interceptors. *Water Research*, 225, 119141. https://doi.org/10.1016/j.watres.2022.119141

Tesprasit, K., Aksharanandana, P., & Kanchanavibhu, A. (2020). Building green entrepreneurship: a journey of environmental awareness to green entrepreneurs in Thailand. *Journal of Information Technology Applications & Management*, *27*(5), 35-47. https://doi.org/10.21219/jitam.2020.27.5.035

Wang, J., & Azam, W. (2024). Natural resource scarcity, fossil fuel energy consumption, and total greenhouse gas emissions in top emitting countries. *Geoscience Frontiers*, *15*(2), 101-757. https://doi.org/10.1016/j.gsf.2023.101757

Yang, J., & Shan, H. (2021). The willingness of submitting waste cooking oil (WCO) to biofuel companies in China: An evolutionary analysis in catering networks. *Journal of Cleaner Production,* 282, 125331. https://doi.org/10.1016/j.jclepro.2020.125331

Yap, C. K., Peng, S. H. T., & Leow, C. S. (2019). Contamination in Pasir Gudang Area, Peninsular Malaysia: What can we learn from Kim Kim River chemical waste contamination? *International Journal of Humanities and Education Development (IJHED)*, *1*(2), 84-87. https://dx.doi.org/10.22161/jhed.1.2.4

Zhang, W., Ji, H., Song, Y., Ma, S., Xiong, W., Chen, C., ... & Zhang, X. (2020). Green preparation of branched biolubricant by chemically modifying waste cooking oil with lipase and ionic liquid. *Journal of Cleaner Production*, 274, 122-918. https://doi.org/10.1016/j.jclepro.2020.122918

Zhang, Y., van Herpen, E., Van Loo, E.J., Pandelaere, M. & Geuens, M. (2023). Save Near-Expired Food: Does a Message to Avoid Food Waste Affect Food Purchase and Household Waste Prevention Behaviours*? Journal of Cleaner Production*, 384, 135-555. https://doi.org/10.1016/j.jclepro.2022.135555

Zhao, F., Schnotz, W., Wagner, I., & Gaschler, R. (2020). Texts and pictures serve different functions in conjoint mental model construction and adaptation. *Memory and cognition,* 48, 69-82. https://doi.org/10.3758/s13421-019-00962-0