

MALAWI UNIVERSITY OF SCIENCE AND TECHNOLOGY

NDATA SCHOOL OF CLIMATE AND EARTH SCIENCE

DEPARTMENT OF EARTH SCIENCES

RESEARCH PROPOSAL SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE BACHELOR OF SCIENCE DEGREE IN PETROLEUM GEOSCIENCES (OIL & GAS)

ASSESSING OIL WASTE MANAGEMENT IN LILONGWE

Yamikani Nyama

(PRE/100/19)

DECLARATION

I, Yamikani Nyama declare that this research project presents my work and that it has never been submitted to this or any other institution for any academic purpose. All the sources used have been acknowledged properly.

Signature: 

Date: November 2023.

DISSERTATION APPROVED BY:

SUPERVISOR:

Fredrick Josiya. 

ASSESSOR:

Title, Initials, Name

Signature:

DISCLAIMER

This document outlines the research conducted as part of an academic program at the Ndata School of Climate and Earth Sciences, which is affiliated with the Malawi University of Science and Technology. The author(s) of this document are solely responsible for the views and opinions expressed within it, and these views and opinions may not necessarily reflect those of the school.

COPYRIGHT STATEMENT

This particular version of the dissertation is provided with the understanding that anyone who refers to it acknowledges the author's copyright and agrees not to publish any quotations from the dissertation or use any information obtained from it without proper acknowledgement.

ABSTRACT

The purpose of this study was to examine the current methods of managing used oil waste in Lilongwe and propose environmentally friendly alternatives if the existing methods were found to be harmful to the environment. The study had three main objectives: firstly, to evaluate how used oil is collected, transported, and stored at garages in Lilongwe; secondly, to assess the effectiveness of current oil waste management practices, including costs and resource utilization; and finally, to suggest environmentally friendly and economically beneficial ways of recycling used oil waste into other usable forms. The research employed two types of data: primary data, which was collected through questionnaires and surveys from individuals and groups in the car servicing industry, and secondary data, which was obtained by reviewing and analyzing articles, journals, and books related to used oil treatment. The inclusion of secondary data provided a broader perspective and enhanced the analysis. The collected data was analyzed using statistical methods, such as using Excel to quantify the relationship between the number of cars and the amount of used oil waste generated. Excel was also used to create graphs, pie charts, and calculate estimates of oil waste generation. The findings revealed that the choice of a method for treating oil waste depends on awareness of the hazards associated with improper handling, which is lacking among many individuals involved in handling used oil in Lilongwe.

AKNOLEDGEMENTS

To begin, I express my gratitude to the divine Lord for His abundant grace, which has sustained me and enabled me to successfully complete my higher education without encountering any obstacles. Additionally, I extend my heartfelt appreciation to my parents, Mr. and Mrs. Nyama, for their unwavering support in terms of finances, emotional guidance, and spiritual encouragement from the very beginning till this present day.

I would also like to extend my heartfelt appreciation to my supervisor, Mr. F. Josiya. Throughout the course of this project, his unwavering support and guidance have been invaluable to me. Whenever I found myself facing challenges or feeling uncertain, he was consistently available to provide me with clear directions and help me find my way. His constant presence and assistance have played a crucial role in the successful completion of this endeavor. I am truly grateful for his dedication and commitment, and I cannot thank him enough for his unwavering support throughout the entire project duration.

In conclusion, I would like to express my gratitude to the individuals who generously contributed their data for the purpose of my research. I must admit that obtaining the necessary data was not without its challenges, particularly due to limited funding. However, through a stroke of good fortune or divine intervention, I managed to conduct a few field trips, which greatly aided my data collection efforts.

During these field trips, I had the opportunity to interact with individuals working in various garages, and I must say that the experience was quite positive. The conversations and interactions I had with these professionals were enriching and insightful. In particular, I thoroughly enjoyed the interview I conducted with the individuals from Toyota Malawi. They extended a warm welcome and were eager to share their knowledge and expertise.

Table of Contents

1.1 Background 9
1.2 Problem Statement 10
1.3 The main objective 11
1.4 Specific Objectives 11
1.5 Research question 12
1.6 Significance of study 12
2.1 Recycling 16
2.2 Re-use 17
2.3 Treating the used oil 19
2.5 Proper disposal 20
3.1 Research design 22
3.2 Data Collection: 22
3.3 Data Analysis: 23
The amount of used oil generated per car or machine 23
The amount of oil waste generated in relation to services per year 24
5.1 Use as fuel 34
5.2 Used to make Porte 34
5.3 Industrial applications 35
5.4 Asphalt production 35
5.5 Metalworking and machining 36
References 38

Chapter 1 General Introduction

1.1 Background

The petroleum sector has witnessed remarkable growth since its inception and has become an integral part of societies, particularly in urban areas (Government, 2023). With this growth, the need to reduce petroleum waste discharge into the environment has garnered significant attention. The importance of addressing this issue was underscored during the World Environment Conference held in Kyoto in 1997 (KYOTO, 1997). It was revealed that, in 1995, less than 45% of available waste oil was being collected globally, indicating that the remaining 55% was either misused or improperly disposed of, resulting in environmental contamination (Khoury, 2001). The improper management of oil waste poses a substantial environmental concern on a global scale, and Malawi is no exception.

Despite not being a major oil producer, Malawi relies heavily on imported petroleum products to meet its energy demands (Taulo.L., 2015). Consequently, the country's increasing demand for oil has led to a surge in oil waste generation, which presents significant environmental risks. The Malawi Environmental Protection Agency (MEPA) has established policies and regulations to manage oil waste; however, the effectiveness and clarity of these measures remain uncertain due to the limited research available on the assessment of used oil waste management methods in Malawi. Inadequate management of used oil waste gives rise to soil, air, and water pollution, which are challenging to remediate (Connell, 1984).Thus, there is an urgent need to evaluate the existing oil waste management practices in Malawi, specifically in Lilongwe, and identify sustainable approaches that promote environmental protection.

This research aims to assess the practices for oil waste management in Lilongwe and propose sustainable approaches that promote environmental protection. Lilongwe,

the vibrant capital city of Malawi, serves as the focal point of this research dissertation, which dig in deep into the critical issue of oil waste management within its urban landscape.

Lilongwe has witnessed remarkable urbanization and economic growth over the past decades. As with many emerging cities in Africa, this transformation has helped in increased industrialization and the proliferation of oil-dependent industries which result in more oil waste generation too. The study will examine the effectiveness of existing oil waste management practices in Lilongwe, including waste collection, transportation, storage and disposal (Programme, n.d.). The research will also identify gaps and areas for improvement.

To achieve this, a combination of quantitative and qualitative research methods will be employed, including surveys, interviews, and case studies (Taherdoost, 2021). These methods will enable a holistic understanding of the existing oil waste management practices in Lilongwe. Furthermore, this research will draw upon existing literature on oil waste management, sustainable development, and environmental protection to provide a comprehensive analysis of the subject matter. The findings of this study will yield valuable insights into the best approaches for managing oil waste, which, in turn, will contribute to the protection of the environment and the promotion of sustainable development.

1.2 Problem Statement

The Republic of Malawi, characterized by its picturesque landscapes and warm-hearted people, has undergone a transformative period of motorization over the past two decades. The remarkable escalation in the country's car population, soaring from 104,800 in 2002, 290,935 in 2015 (KAUNDA, 2018), has painted a portrait of rapid urbanization and economic growth. This trend, however, casts a looming shadow over the nation's environmental and public health landscape, as it is inextricably linked to the simultaneous surge in used oil production—a hazardous waste with

profound consequences if mishandled (Katiyar.V, 2010). As projections indicate an imminent triple increase in the car population by 2036, 704,000, the urgency of addressing this problem cannot be ignored.

Used oil, a byproduct of automotive operations, contains a cocktail of potentially toxic substances, including heavy metals, polycyclic aromatic hydrocarbons (PAHs), and other contaminants (Syrmanova K.K, 2017). When improperly managed, these hazardous compounds have negative environmental effects, that is to say, contaminating soils, water bodies, and adversely affecting biodiversity. Equally concerning are the grave health risks it poses to human populations exposed to such pollutants, including cancer, respiratory ailments, and skin disorder (Shigenaka, 2011). Therefore, this study aims to bridge the gap in knowledge by evaluating and reviewing the existing oil waste management practices in Lilongwe.

1.3 The main objective

The research will aim at assessing oil waste management practices current in use in Lilongwe.

1.4 Specific Objectives

I. To assess how used oil is collected, transported and stored in Lilongwe
II. To assess the efficiency of current oil waste management practices in Lilongwe, including costs and resource utilization.
III. To suggest environmentally friendly and economical beneficial ways of recycling used oil waste

1.5 Research question

This study will answer the following questions;

I. How is oil waste collected and transported in Lilongwe?
II. How is used oil waste currently managed in Lilongwe, and what are the most commonly used methods and technologies?
IV. What are the environmentally friendly and economical beneficial ways of recycling used oil waste?

1.6 Significance of study

This research endeavor holds significant promise as it aims to generate a wealth of valuable information regarding the management of oil waste, focusing on both effectiveness and efficiency. By delving into this subject, the research will uncover a multitude of insights that can revolutionize the industry's approach to oil waste management.

One of the primary objectives of this research is to identify the limitations and drawbacks of the current methods employed in oil waste management (Rashid, 2023). By examining the existing practices, the study will shed light on their shortcomings, thereby highlighting areas that require improvement. This critical analysis will contribute to a comprehensive understanding of the challenges faced by stakeholders in the industry.

Moreover, the research will not only focus on the identification of limitations but also emphasize the development of more effective and efficient practices. By exploring innovative strategies and technologies, the study will provide practical recommendations that can enhance the industry's ability to manage oil waste in a sustainable manner (EL-Fadel, 2001). These recommendations may include improved treatment processes, advanced disposal techniques, or the adoption of alternative energy sources to minimize waste generation.

The findings of this research will serve as a valuable resource for policymakers, enabling them to make informed decisions regarding oil waste management regulations and guidelines. By incorporating the research outcomes into policy frameworks, governments can promote environmentally friendly practices and ensure the responsible disposal of oil waste. This alignment between research and policy will help strike a balance between the economic benefits of the oil industry and the preservation of the environment.

Furthermore, the research outcomes will extend beyond the industry itself, benefiting a broader range of stakeholders. By disseminating the research findings to relevant parties, such as regulatory bodies, environmental organizations, and other industries, the knowledge gained from this study can be utilized to develop comprehensive frameworks for environmentally friendly oil waste disposal. These frameworks will not only ensure compliance with environmental standards but also contribute to the overall well-being of the country.

Chapter 2 Literature Review

Oil waste management plays a crucial role in safeguarding the environment and promoting environmental conservation. It encompasses various processes and strategies aimed at preventing the harmful effects of oil production and usage on ecosystems and human health. By effectively managing oil waste, it becomes possible to minimize pollution and mitigate the negative impact on the environment.

In the context of Lilongwe, the capital city of Malawi, oil waste management remains a significant challenge primarily due to the limited availability of resources required to implement the best practices. This lack of resources hinders the adoption of efficient and environmentally friendly technologies and techniques for managing oil waste. Consequently, the improper disposal and treatment of oil waste can lead to

environmental contamination, posing risks to both ecosystems and human well-being (Biswick, 2022). Notably, Lilongwe's struggle with oil waste management is not an isolated issue. Many other developing countries, especially densely populated Asian nations with lower gross domestic products (GDP) such as the Philippines, Malaysia, Thailand, and Sri Lanka, also face similar resource constraints. These countries often find it challenging to afford expensive technologies and infrastructure necessary for effective oil waste management. As a result, they encounter difficulties in ensuring that oil waste is handled properly to minimize environmental harm.

To gain insights into the existing practices for managing oil waste and their effectiveness in protecting the environment and human health, a literature review was conducted. This review aimed to assess the current state of oil waste management strategies utilized in various regions. By examining the available literature, it becomes possible to identify the strengths and weaknesses of different approaches and propose potential improvements.

The literature review delves into diverse aspects of oil waste management, including waste collection, transportation, storage, and disposal methods. It explores the utilization of technologies, such as centrifugation, filtration, and chemical treatment, to separate and treat oil waste effectively. Additionally, the review investigates the implementation of regulatory frameworks and policies pertaining to oil waste management and their impact on environmental conservation efforts.

One of the key stages in used oil waste management is waste collection. This involves gathering the waste generated during various oil-related activities, such as drilling, refining, and transportation. Proper waste collection ensures that the waste is centralized and can be effectively managed. After collection, the waste needs to be transported to appropriate facilities for treatment and disposal. Transportation methods may vary depending on the volume and nature of the waste. It is essential to

ensure safe and efficient transportation to prevent spills or leaks that could harm the environment.

Storage plays a significant role in oil waste management. Waste storage facilities are designed to safely hold the waste until it can be treated or disposed properly. These facilities must meet certain standards to prevent leakage or contamination of surrounding soil and water sources.

The review also discusses various methods used for the treatment of oil waste. Technologies such as centrifugation, filtration, and chemical treatment are employed to separate impurities and contaminants from the waste. Centrifugation involves the use of centrifugal force to separate solid particles from the liquid waste. Filtration uses porous materials to trap solid particles while allowing the liquid to pass through. Chemical treatment involves the use of specific chemicals to break down or neutralize harmful substances in the waste.

By employing these treatment technologies, oil waste can be effectively purified, removing harmful contaminants and impurities. This purification process is crucial for ensuring the waste is safe for disposal or potential reuse. It minimizes the environmental impact of oil waste and reduces the risk of contamination to soil, water bodies, and ecosystems.

To address the complex challenges associated with oil waste management, a range of methods has been implemented worldwide. These methods encompass diverse approaches, including recycling, reuse, treatment, and proper disposal. The effectiveness of each method heavily relies on several crucial factors, such as the specific type and volume of oil waste being handled.

2.1 Recycling

Recycling stands as a prominent technique employed to manage oil waste. This process involves the reprocessing of used oil, enabling its conversion into usable products. Recycling can take different forms, such as re-refining which involves multiple steps such as flash evaporation, defueling, lube distillate separation, and hydro-finishing, where impurities and contaminants are removed from the waste oil to produce base oil suitable for reuse. Here is a step-by-step process how, re-refining is done;

I. **Flash Evaporation**: The first step in re-refining involves heating the used oil to evaporate water and volatile components. This process, known as flash evaporation or dehydration, helps remove the water content from the oil (KYOTO, 1997).

II. **Defueling**: After flash evaporation, the oil undergoes defueling, which involves removing gasoline, diesel, and other lighter fuels that may be present in the used oil. These fuels can be recovered and reused separately (KYOTO, 1997).

III. **Lube Distillate Separation**: The next step is lube distillate separation, where the remaining oil is heated to separate it into different fractions based on their boiling points. This process allows for the removal of contaminants and impurities that have higher or lower boiling points than the desired lubricating base oil (Taulo.L., 2015).

IV. **Hydro-finishing**: Once the lube distillate separation is complete, the separated oil undergoes hydro-finishing. This step involves subjecting the oil to hydrogen treatment under specific conditions, such as high temperature and pressure, to further remove impurities and improve the quality of the base oil (EL-Fadel, 2001).

The re-refining process requires energy and material inputs such as natural gas, electricity, hydrogen, and catalysts (JRP, 2022). These inputs help facilitate the various steps involved in transforming used oil into high-quality lubricating base oil.
For instance, in California, the process model suggests that 12 million gallons of used oil, with a water content of 4-5%, can be annually processed using 1 liter of dry used oil as input (Calrecycle, 2022). This demonstrates the potential scale of oil waste management through re-refining.

Re-refining recovers high-purity lubricating base oil from used oil, which can replace virgin lube base oil. The recycled oil can be reused, reducing the demand for new oil and minimizing waste generation. However, it is important to note that the quality of the recycled oil is crucial. Despite the re-refining process, there is still a possibility of the recycled oil containing impurities and contaminants. These impurities can be harmful to the environment and human health. Therefore, it is essential to employ stringent quality control measures to ensure that the recycled oil meets the necessary standards before it is reused or reintroduced into the market.

2.2 Re-use

Re-use is another approach for handling used oil waste. The, re-use of used oil waste is a highly beneficial and environmentally conscious approach that effectively addresses the challenges of waste management and resource conservation. By repurposing used oil for alternative applications, such as a lubricant, fuel source, or in various industrial processes, we can significantly reduce the volume of waste generated and concurrently save valuable resources (Brown, 2016). Before the re-use of used oil, it is crucial to subject it to thorough filtration and treatment processes. These steps are essential for eliminating impurities and contaminants that may have accumulated during the oil's initial use. By removing these unwanted substances, the quality and performance of the reused oil are enhanced, ensuring its effectiveness in the intended applications.

One of the primary advantages of reusing used oil waste is the substantial cost savings it offers. Instead of purchasing new lubricants or fuels, industries and businesses can utilize the reclaimed oil, thus reducing their expenses. This cost-effective approach not only benefits the companies involved but also contributes to overall economic efficiency.

Moreover, the re-use of used oil waste plays a vital role in waste reduction. By diverting used oil from traditional disposal methods, such as landfilling or incineration, significant amounts of waste can be prevented from entering the waste stream. This reduction in waste volume positively impacts the environment by conserving landfill space, minimizing the need for incineration, and reducing associated emissions.

Additionally, the environmental impact of industrial operations can be mitigated through the reuse of used oil waste. By opting for this sustainable practice, industries can minimize their reliance on virgin resources, which often involve resource-intensive extraction and processing methods. Consequently, the overall carbon footprint and ecological strain associated with the production and transportation of new lubricants or fuels are significantly reduced.

However, it is of utmost importance to ensure that the reuse of used oil waste is carried out safely and responsibly. Adhering to regulatory requirements and following best practices is crucial to prevent any potential risks to human health and the environment. This includes implementing appropriate filtration and treatment techniques, maintaining robust quality control measures, and monitoring the reused oil throughout its lifespan to ensure optimal performance and safety.

2.3 Treating the used oil

Treatment is a crucial and vital method for managing used oil waste, as it plays a significant role in reducing the environmental impact of waste oil. The primary objective of treatment is to remove contaminants and harmful substances from the oil, thereby minimizing the potential harm it can cause to the environment and human health (Zhang, 2012). Various treatment methods exist, and the selection of a particular method depends on the type and level of contamination present in the oil. Physical, chemical, and biological processes are commonly employed in oil waste treatment.

Physical methods involve the separation of oil from other contaminants through processes such as centrifugation, sedimentation, and filtration (Johnson, 2019). Centrifugation utilizes the principle of centrifugal force to separate oil and contaminants based on their density differences. Sedimentation allows the heavier contaminants to settle down while the oil floats to the top. Filtration involves passing the oil through filters that trap the solid contaminants, allowing the purified oil to pass through.

Chemical treatments, on the other hand, employ the use of additives to facilitate the removal of contaminants from the oil. Solvents or surfactants are commonly used in this process to dissolve or emulsify contaminants, making them easier to remove. For instance, flocculants or coagulants can be used as chemical treatment methods for oil waste. These chemicals cause contaminants to clump together, enabling their separation from the oil (Janks JS, 1992).

Once the contaminants are separated from the oil, additional treatment methods like filtration or incineration may be employed for further purification or disposal. It is crucial to ensure that the chemicals used in the treatment process are safe and do not pose any harm to the environment or human health. Adherence to regulatory

requirements and best practices is essential when utilizing chemical treatments for oil waste management (Greenwood, 2022).

Another approach to oil waste treatment is biological treatment, which utilizes microorganisms to break down or transform contaminants present in the waste oil (Mishra S, 2001). Bioremediation, for example, employs microorganisms to degrade hydrocarbons found in waste oil into less harmful substances. This process is typically carried out in a controlled environment, such as a bioreactor. Biological treatment is considered eco-friendly and sustainable; however, its effectiveness may vary depending on factors such as the type and concentration of contaminants, nutrient availability, and environmental conditions (Editions, 2023).

Treatment processes can be conducted either on-site or off-site at specialized facilities. However, it is important to note that treatment can be costly and may not always achieve complete removal of all contaminants. The efficiency of treatment processes typically ranges around 50%. However, by optimizing microbial growth conditions and other factors, the efficiency can be increased (Ward O, 2003). Therefore, adherence to regulatory requirements and best practices is crucial to ensure that oil waste treatment is carried out in a safe, efficient, and sustainable manner.

2.5 Proper disposal

Proper disposal is considered the last resort in the management of used oil waste due to its potential environmental and health impacts. The period from 1973 to 1983 witnessed various methods of disposing of drilling sludge waste, with landfilling accounting for 50-40% of the disposal, followed by lagoons (40-19%), land forming (9-34%), and incineration (1-3%) (Hu G, 2013). Over time, there has been a shift in disposal practices, with onsite disposal rates increasing from 44% to 73%, while offsite disposal rates decreased from 56% to 27% (Hu G, 2013).

Among the different methods used to dispose of used oil waste, incineration is often considered the most preferable. When oil sludge is incinerated, it undergoes a process where it is burned with a flammable component and oxygen, resulting in a decrease in volume. This process effectively removes toxins and heavy metals from the oil waste, leaving behind ash. The high temperatures, ranging from 700 to 1200°C, break down the heavy molecules of the oil sludge into smaller ones. The combustion process can last anywhere from 30 minutes to several days and is typically carried out in a fluidized reactor or rotary kiln (Teng Q, 2021).

However, it is important to note that while disposal methods like incineration can be effective, they should be minimized and alternative options such as recycling and reuse should be explored. The disposal of used oil waste should adhere to best practices and regulatory requirements at the local, state, and federal levels to ensure that it is done safely and in a sustainable manner.

By prioritizing recycling and reuse, the environmental and health impacts associated with oil waste disposal can be significantly reduced. Recycling used oil waste allows for the recovery of valuable resources and reduces the need for raw materials. Additionally, reusing used oil waste in appropriate applications can help minimize its overall environmental footprint.

To ensure the safe and responsible disposal of used oil waste, it is crucial for industry and regulatory bodies to collaborate and develop comprehensive waste management strategies. These strategies should focus on reducing waste generation, promoting recycling and reuse, and implementing stringent monitoring and control measures to safeguard the environment and public health.

Meanwhile, disposal is sometimes necessary for managing oil waste, it should be considered as a last resort. Instead, emphasis should be placed on exploring recycling and reuse options to minimize the environmental and health impacts associated with oil waste. By following best practices and regulatory requirements, the disposal of oil waste can be carried out in a safe and sustainable manner, ensuring the protection of our environment for future generations.

Chapter 3 Methodology

3.1 Research design

The research design chosen for this study was a descriptive research design, which aimed to provide a comprehensive understanding of the various ways and methods employed in Lilongwe for the treatment of used oil waste. Multiple garages were surveyed in order to gather data on their practices and procedures for handling and managing used oil waste. This design was specifically selected because the primary objective of the study was to evaluate the current practices of oil waste management in Lilongwe.

In order to accomplish the research objectives, a quantitative research method was utilized. This approach involved the systematic and objective collection, analysis, and interpretation of numerical data. By employing quantitative methods, the study enabled statistical analysis and the ability to generalize the findings to a larger population or context (Giovanni, 2022).

3.2 Data Collection:

The research conducted in this study utilized two distinct types of data; primary data and secondary data. Primary data was gathered directly from individuals or groups working in the car servicing industry using questionnaires and surveys. This method allowed for the collection of firsthand information that was specifically tailored to the

research objectives. The study aimed to understand the strategies employed in treating used oil in Lilongwe, and it was found that reusing the used oil was the most common method. This was primarily due to the lack of resources and funding, as other methods were deemed costly. The study also explored the handling and transportation practices associated with oil treatment.

In contrast, secondary data was obtained by extensively reviewing and analyzing various articles, journals, and books that provided insights into the treatment of used oil. This approach facilitated the exploration and integration of existing knowledge and findings from previous studies conducted by other researchers. By examining a wide range of scholarly sources, the study was able to benefit from the wealth of information already available, thus enhancing the overall comprehensiveness of the research. The inclusion of secondary data allowed for a deeper understanding of the topic and enriched the analysis by incorporating a broader perspective.

3.3 Data Analysis:

The collected data was analyzed using the Statistical Package for Social Scientists (SPSS), a software program commonly used for statistical analysis. This analysis involved generating frequency tables, charts, and descriptive statistics to examine the data.

The amount of used oil generated per car or machine

The quantity of used oil produced by individual vehicles and machines varies depending on their size and type. In the case of heavy machinery and trucks, including coaches, a substantial amount of used oil is generated. Typically, during a single service, these larger vehicles produce approximately 15 to 20 liters of used oil. Considering the overall number of cars and machines in Malawi, this volume of used oil is quite significant.

In contrast, smaller luxury cars and saloons generate a comparatively smaller amount of used oil. On average, these vehicles produce between 2 to 4 liters of used oil per service. Furthermore, motorcycles, being smaller in size, generate even less used oil,

with an average of half a liter produced after a service. Therefore, the amount of used oil generated varies depending on the type and size of the vehicle or machine in question.

The amount of oil waste generated in relation to services per year

The quantity of oil waste produced in proportion to services on an annual basis varies depending on the vehicles involved. Trucks and other machinery generate a significant amount of used oil since they release more oil per service and can undergo maintenance three to five times per year, depending on their usage. In contrast, luxury saloon cars generate a smaller amount of used oil per service, but they require more frequent servicing, typically after traveling 5,000 to 10,000/15,000 kilometers (KAUNDA, 2018). These luxury cars contribute approximately 3 liters. On the other hand, motorcycles contribute half a liter per service and they can be serviced every month.

Estimated amount of used oil generated on a day after service in Lilongwe

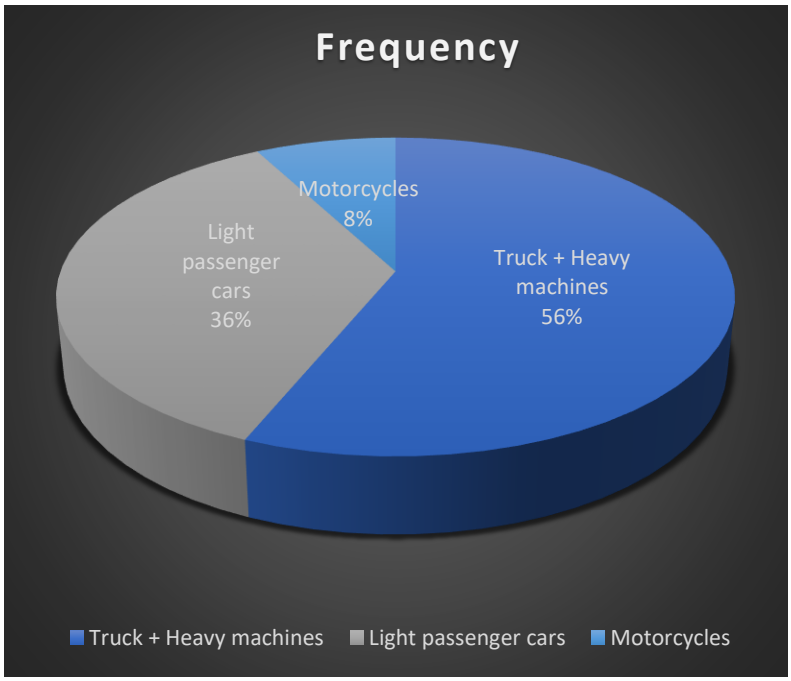
Car Type	Percentage by Liters	Volume
Trucks	52.25*15	783.73L
Luxury Saloons	38.89*3	116.67L
Motorcycles	8*0.5	4L
Total		**904L**

The research findings indicate that a significant portion of the oil, specifically 52.25%, is generated from trucks and other heavy machines following their service. Light passenger cars, including saloon cars and min-buses, contribute 38.89% of the generated oil. The remaining 8.86% is generated by motorcycles (Kaunda, 2016).

Table 1; Showing used oil sources

Source	Frequency	Percentage
Truck + Heavy machines	36	52.25%
Light passenger cars	23	38.89%
Motorcycles	5	8.86%
Total	**64**	**100%**

A graph; Showing used oil sources

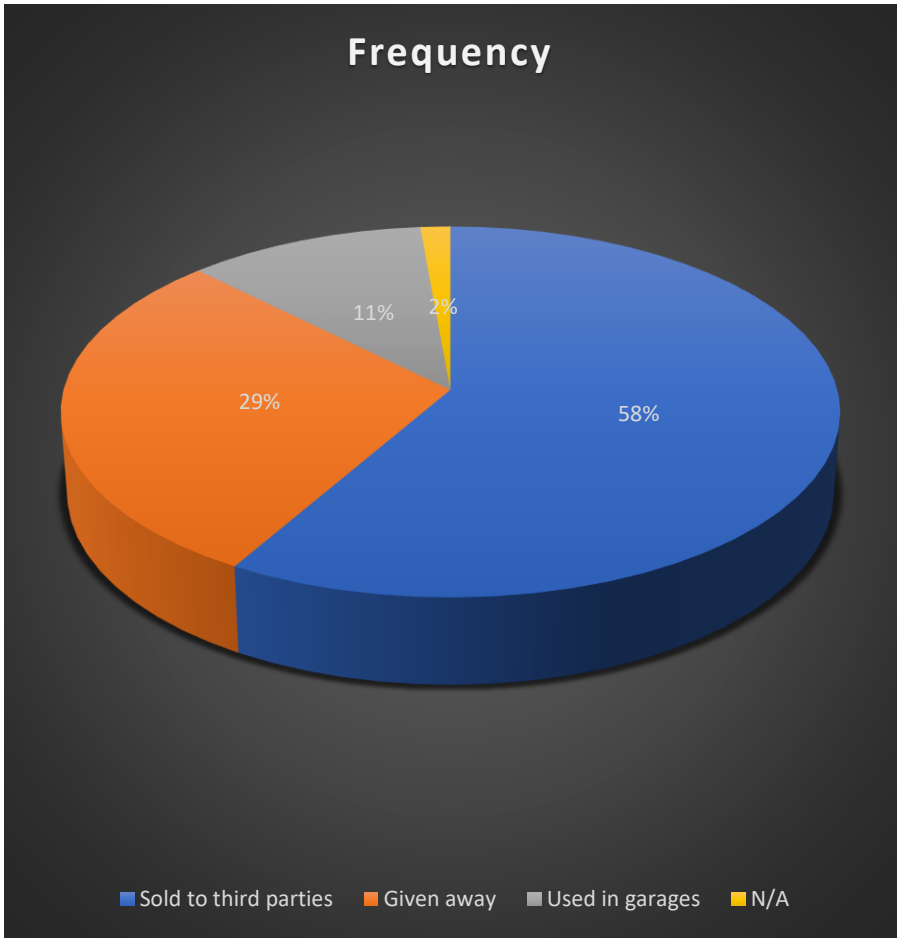


Regarding the disposal of the oil left behind by these vehicles, the study revealed several patterns. A substantial proportion, approximately 48.6%, of the used oil is sold to third parties at low prices. Additionally, about 36.9% of the used oil is given away freely to individuals. In some cases, approximately 11.3% of the used oil is reported to be utilized within garages. However, a concerning 3.2% of the oil is mishandled or improperly managed.

Table: Showing how used oil is managed

Strategy	Frequency	Percentage
Sold to third parties	42	48.6%
Given away	21	36.9%
Used in garages	8	11.3%
N/A	1	3.2%
Total	**72**	**100%**

A graph Showing how used oil is managed



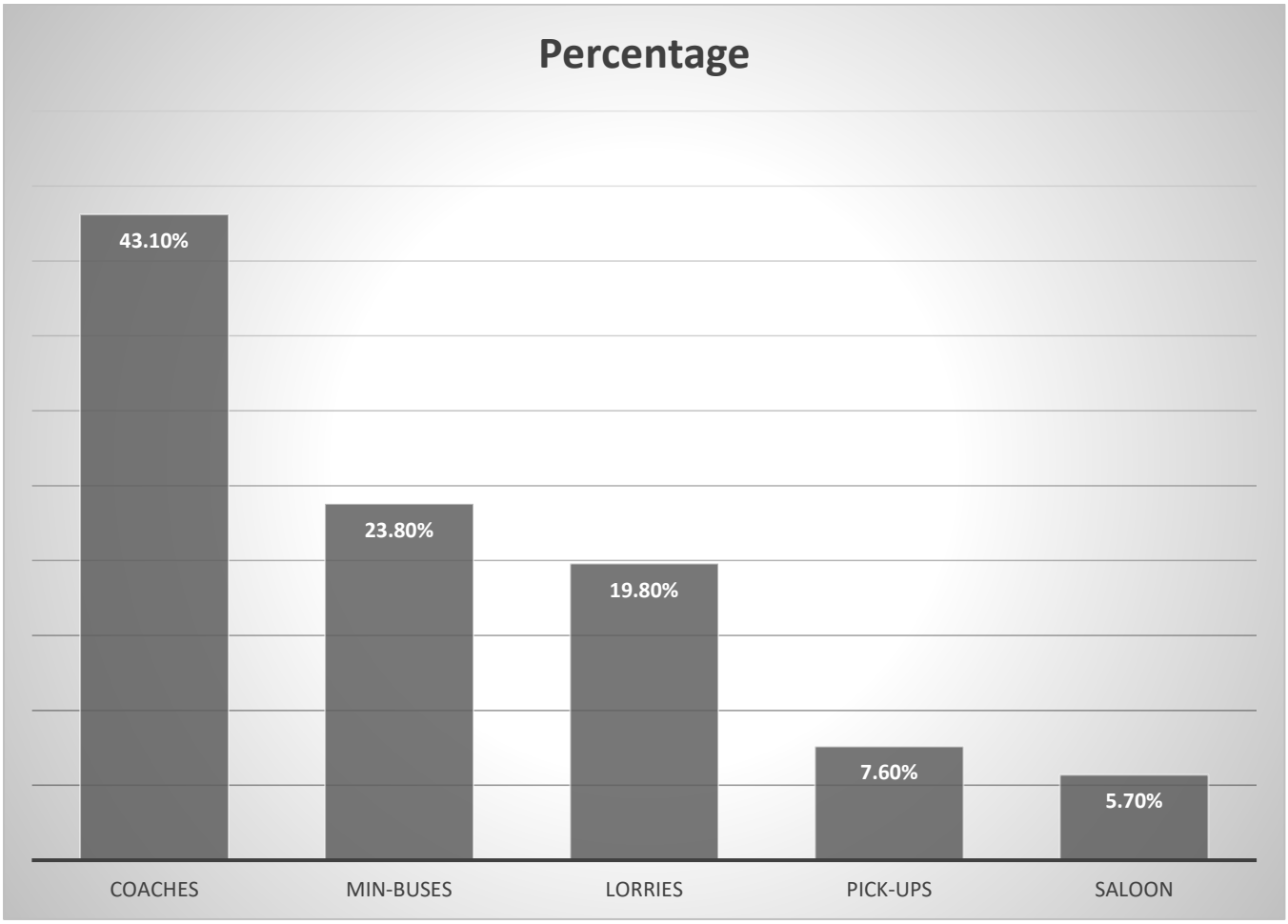
Types of Cars serviced

Coaches undergo oil changes at a higher frequency compared to all other types of vehicles combined. According to the provided table, coaches accounted for 43.1% of the serviced motor vehicles. In contrast, minibuses represented 23.8% of the serviced vehicles, lorries accounted for 19.8%, pick-ups made up 7.6%, and saloon cars plus motorcycles comprised only 5.7% of the serviced vehicles.

A table showing type of vehicle serviced

Vehicle type	**Percentage**
Coaches	43.1%
Min-buses	23.8%
Lorries	19.8%
Pick-ups	7.6%
Saloon + Motorcycles	5.7%3
Total	**100%**

A graph showing car type service



Chapter 4 Results and discussion

An interview was conducted with workers from Toyota Malawi, one of the leading car servicing companies in the industry, to understand how they manage used oil in their working environment. The interview revealed that Toyota Malawi has implemented a comprehensive set of procedures to ensure proper handling of used oil waste.

To begin with, the used oil is carefully collected in containers to prevent any spillage or contamination. Once collected, the oil is stored in a large tank, which serves as a centralized storage facility. This centralized approach allows for efficient management and easy access to the used oil.

A picture showing a storage tank for used oil.



Site visits to various garages revealed that, none have used oil tanks; only big companies like Toyota Malawi have bigger storage tanks. Collection of oil by these garages is purely intended for sale. So, when these small garages cannot find outlets, all the oil would be poured away to create room for fresh one since they do not have anywhere to keep it. Lilongwe garages are most notorious for water pollution. Asked if they knew the dangers of handling used oil without protection, most mechanics had no idea that there were any. It is clear that public awareness of the dangers posed by used oil is need as a matter of urgency.

Pictures showing used oil contaminated water in Lilongwe River



The lack of complete mixing between oil and water is evident, likely due to their differing densities. This explains why the remnants of the used oil waste are visibly shimmering on both the sand and the water.





Interestingly, Toyota Malawi also has an alternative method for treating oil that has mixed with water or has spilled on the ground during the draining process. They employ oil separators, which are specialized devices designed to effectively remove oil from water. These separators play a crucial role in the cleaning process, particularly when dealing with spills and the cleaning of materials. By utilizing these separators, Toyota Malawi ensures that oil and water are properly separated, as oil has a higher density and tends to settle down, making it easier to remove.

Once the oil and water have been successfully separated, the water is disposed of in a responsible manner. Toyota Malawi takes the necessary steps to ensure that the water, which may contain traces of oil, is not released into the environment without proper treatment. Instead, the water is disposed of by being appropriately discarded into the Lilongwe River. This disposal method ensures that any potential environmental impact is minimized, as the oil content in the water has been significantly reduced through the separation process.

Toyota Malawi's approach to managing used oil demonstrates their commitment to environmental responsibility and sustainability. By adhering to strict procedures and utilizing specialized equipment such as oil separators, they effectively handle used oil and prevent its improper disposal. This responsible management of used oil contributes to the company's reputation as a leader in the industry and sets an example for other car servicing companies to follow.

Chapter 5 Economical ways of getting rid of used oil waste

5.1 Use as fuel

Used oil can be repurposed as a fuel source by blending it with other substances and burning it to harness its energy. This process commonly takes place in various settings, including furnaces, smelters, and even local garages where they utilize it for cooking purposes. It's important to note, though, that the conditions within these furnaces and other burning facilities may not ensure the complete elimination of harmful impurities present in the used oil. While burning used oil has become a well-established practice in Lilongwe and other areas, it does not guarantee the thorough destruction of all detrimental components contained within the oil.

In addition to being utilized in furnaces and smelters, used oil can also be employed as a fuel in certain industrial processes, such as power generation and cement production. These industries have implemented technologies to appropriately handle and burn used oil, adhering to regulatory guidelines to minimize environmental impacts.

5.2 Used to make Porte

Porte is a specialized material that finds its application primarily in the construction industry, specifically for bonding glass components. Its unique formulation consists of two key ingredients: limestone and used oil.

Limestone, a sedimentary rock abundant in nature, plays a crucial role in the production of Porte. It is first processed into a fine powder to enhance its reactivity and facilitate its incorporation into the Porte mixture. The powdered limestone acts as a filler, imparting desirable characteristics to the final product.
Used oil, on the other hand, serves as a binding agent in the Porte formulation. It is typically obtained from recycled or reclaimed sources and undergoes appropriate treatment to ensure its suitability for use in the construction industry. The used oil not

only aids in the cohesion of the Porte material but also contributes to its overall adhesive properties, allowing for effective bonding of glass components.

When manufacturing Porte, the powdered limestone is carefully blended with the used oil, ensuring a homogenous mixture. The proportions of these ingredients are determined based on the desired properties and performance requirements of the final product. The mixture is then processed through various methods such as mixing, heating, and curing to achieve the desired consistency and adhesive characteristics.

Once the Porte material is ready, it can be applied to glass surfaces during construction projects. Its adhesive properties enable secure bonding of glass components, such as windows, doors, or glass panels, to various structural elements. This ensures structural integrity, weather resistance, and durability of the glass installations.

5.3 Industrial applications

Recycled oil finds application in various industrial processes. It can be used as a lubricant and coolant in metalworking operations such as machining, drilling, and cutting. Additionally, it can be used as a release agent and mold lubricant in the manufacturing of products like rubber, plastic, and metal components.

5.4 Asphalt production

Asphalt production is the process of creating asphalt, which is a mixture of aggregates (such as crushed stone, sand, or gravel) and a binder called bitumen. Bitumen is a sticky black substance derived from crude oil and is commonly used in road construction for its adhesive properties.

Recycled oil can be utilized as a binder in asphalt production, meaning it can be mixed with bitumen to enhance the performance and durability of the asphalt

mixture. The process typically involves blending the recycled oil with the bitumen at appropriate ratios to achieve the desired properties.

By incorporating recycled oil into asphalt production, several benefits can be realized. Firstly, it helps reduce the reliance on virgin oil, which is traditionally used as a binder in asphalt production. By substituting a portion of the virgin oil with recycled oil, fewer natural resources are consumed, leading to conservation efforts.

Additionally, the use of recycled oil in asphalt production contributes to environmental sustainability. Recycling oil prevents it from being disposed of improperly or ending up in landfills or waterways, which can have detrimental environmental effects. By reusing the oil in asphalt production, its usefulness is extended, and its potential negative impacts are minimized.

Furthermore, incorporating recycled oil into asphalt can enhance the performance and durability of the resulting pavement. The addition of recycled oil can improve the flexibility, resistance to cracking, and overall longevity of the asphalt mixture. This can lead to longer-lasting roads and reduced maintenance needs, resulting in cost savings over time.

5.5 Metalworking and machining

Metalworking and machining are industrial processes used to shape and manipulate metal materials into desired shapes and sizes. These processes involve cutting, grinding, milling, drilling, and other operations to remove material and create final products.

One crucial aspect of metalworking and machining is the use of cutting or grinding fluids, also known as coolants. These fluids are applied during the machining process to lubricate the tool and workpiece, reduce friction, dissipate heat, and improve the surface finish of the machined parts. They help prevent excessive tool wear, minimize workpiece deformation, and enhance the overall machining efficiency.

Traditionally, cutting fluids were petroleum-based oils or synthetic fluids specially formulated for metalworking applications. However, the disposal of these fluids after use poses environmental concerns due to their potential contamination with metals, chemicals, and other pollutants. To address these issues and promote sustainability, the recycling of oil-based cutting fluids has gained popularity in metalworking operations.

Recycled oil, obtained through a reclamation process, can be utilized as a viable alternative to conventional cutting fluids. The reclamation process involves filtering, purifying, and treating used cutting fluids to remove contaminants and restore their performance properties. This recycled oil can then be reintroduced into the metalworking process.

Using recycled oil as a cutting or grinding fluid offers several benefits. Firstly, it helps minimize waste generation by extending the life cycle of the cutting fluid. Instead of discarding the fluid after a single-use, it can be reclaimed and reused multiple times, reducing the overall amount of waste generated.
Secondly, recycled oil as a coolant contributes to sustainability efforts. By reusing oil, manufacturers can reduce their reliance on virgin resources and decrease the environmental impact associated with the production and disposal of conventional cutting fluids.

Furthermore, recycled oil can provide comparable performance to its virgin counterparts. It effectively lubricates the cutting tool and workpiece, thereby reducing friction and heat generation during the machining process. This helps prevent tool wear, enhance tool life, and improve the dimensional accuracy and surface finish of machined parts.

References

Biswick, J. N. (2022). Opportunities and challenges associated with municipal solid waste disposal: A case study of Malawi cities. *International Journal of Environment Quality*, 1-12.

Brown, T. (2016, November 25). *energylogic*. Retrieved from energylogic.com: https://www.energylogic.com/waste-oil-innovative-energy-sources-uses-industrial-processes/

Calrecycle. (2022). *calrecycle.ca.gov*. Retrieved from htt://www.calrecycle.ca.gov

Connell, D. W. (1984). *Chemistry and Ecotoxicology of Pollution.* New York: John Wiley and Sons.

Editions, M. (2023, March 27). *microbiologynote*. Retrieved from microbiologynote.com: https://microbiologynote.com/bioremediation/

EL-Fadel, M. (2001). Strategies for vehicle waste-oil management; a case study. *Resources, Conservation and Recycling*, 75-91.

Frechtling, J. (2002). An overview of quantitative and qualitative data collection methods. In *The 2002 user-friendly handbook for project evaluation* (pp. 43-62).

Giovanni, N. (2022). Assesingthe role of community members in waste disposal in Lilongwe. *African Journal of Environmental Science and technology*, 111-125.

Government, U. S. (2023, March 29). *United Environmental Protection Agency*. Retrieved from epa.com: https://www.epa.gov/hw/management-oil-and-gas-exploration-and-production-waste

Greenwood, J. (2022, February 2). *WCS Group*. Retrieved from https://www.wcs-group.co.uk/wcs-blog/coagulants-flocculants-wastewater-treatment

Hox, J. J. (2005). *Data collection, primary versus secondary Encyclopedia of social Measurement.* Elsevier.

Hu G, L. J. (2013). Recent development in the treatment of oily sludge from petroleum industry. *Journal of Hazardous mMaterials* , 470–90.

Janks JS, C. F. (1992). Investigations into the use of modified zeolites for removing benzene, toluene, and xylene from saline produced water. 473–87.

Johnson, O. A. (2019). Petroleum sludge treatment and disposal. *Petroleum sludge treatment and disposal: A review*, 191-201.

JRP. (2022). *JRP oil service*. Retrieved from jrpoilservice: http://www.jrpoilservice.com

Kabir, S. M. (2016). Methods Of Data Collection. In S. M. Kabir, *Basic Guidelines for Research; An Intoductory Approach for All Disciplines* (pp. 201-275).

Katiyar.V, H. (2010). Environmental Impacts of Used Oil.

Kaunda, C. (2016). *Malawi Vehicle Growthrate and Population.* Lilongwe: Ministry of Transport and Public Works.

KAUNDA, C. (2018). *MALAWI VEHICLE POPULATION AND GROWTH RATES*. Retrieved from https://wedocs.unep.org/bitstream/item/21643/Malawi%20Vehicle%20Population%20and%20Growth%20Rates%2C%20Chimwemwe%20Kaunda%2C%20Ministry%20of%20Transport%20and%20Public%20Works%20Malawi.pdf?sequence=5

Khoury, M. E.-F. (2001). A case study, resources, Conservation and Recycling. *Strategies for Vehicle Waste oil Management*, 75-91.

KYOTO. (1997, December 1). *United Nations*. Retrieved from Retrieved from press.un.org: http://pree.un.org/en/19971202.EN

Mishra S, J. J. (2001). In situ bioremediation potential of an oily sludge-degrading bacterial consortium. *Curr Microbiol 1*, ;43(5):328–35.

Pandey, P. &. (2015). *Research Methodology: Tools and Techniques.* Romania: Bridge center.

Programme, U. N. (n.d.). *wedocs.unep.org*. Retrieved from https://wedcos.unep.org.

Rashid, N. (2023). A review of waste management approches to maximise sustainable value of waste from the oil and gas industry and potential for the state of Qatar. *Fuel*, 126220.

Shigenaka. (2011). Effects of Oil in the Environment. *Oil Spill Science and Technology*, 985-1024.

Syrmanova K.K, K. A. (2017). Oriental Journal of Chemistry. *Chemistry and Recycling Technology of Used Motor Oil*, 33.

Taherdoost, H. (2021). A Step-by-Step Guide to Choose Data Collection Technique for Academic and Business Research Projects. *Data Collection Methods and Tools for Research*, 10-38. Retrieved from www.scribber.com: https://www.scribber.com

Taulo.L., G. a. (2015). Energy Supply in Malawi. *Journal of Energy in Southern Africa*. Retrieved from CEIC: www.ceicdata.com

Teng Q, Z. D. (2021). A review of the application of different treatment processes for oily sludge. *Environ Sci Pollut Res* , 121–32.

Ward O, S. A. (2003). Accelerated biodegradation of petroleum hydrocarbon waste. *J Ind Microbiol Biotechnol*, ;30(5):260–70.

Zhang, J. (2012). Treatment of refinery oily sludge using ultrasound, bio-surfactant, and advanced oxidation processes.

Brown, T. (2016, November 25). *energylogic*. Retrieved from energylogic.com: https://www.energylogic.com/waste-oil-innovative-energy-sources-uses-industrial-processes/

Connell, D. W. (1984). *Chemistry and Ecotoxicology of Pollution.* New York: John Wiley & Sons.

Editions, M. (2023, March 27). *microbiologynote*. Retrieved from microbiologynote.com: https://microbiologynote.com/bioremediation/

Frechtling, J. (2002). An overview of quantitative and qualitative data collection methods. In *The 2002 user-friendly handbook for project evaluation* (pp. 43-62).

Greenwood, J. (2022, February 2). *WCS Group*. Retrieved from https://www.wcs-group.co.uk/wcs-blog/coagulants-flocculants-wastewater-treatment

Hox, J. J. (2005). *Data collection, primary versus secondary Encyclopedia of social Measurement.* Elsevier.

Hu G, L. J. (2013). Recent development in the treatment of oily sludge from petroleum industry. *Journal of Hazardous mMaterials* , 470–90.

Janks JS, C. F. (1992). Investigations into the use of modified zeolites for removing benzene, toluene, and xylene from saline produced water. 473–87.

Johnson, O. A. (2019). Petroleum sludge treatment and disposal. *Petroleum sludge treatment and disposal: A review*, 191-201.

Kabir, S. M. (2016). Methods Of Data Collection. In S. M. Kabir, *Basic Guidelines for Research; An Intoductory Approach for All Disciplines* (pp. 201-275).
Katiyar.V, H. (2010). Environmental Impacts of Used Oil.
Khoury. R, E.-F. M. (2001). Strategies for vehicle waste-oil management; a case study. *Resources, Conservation and Recycle*, 75-91.
Mishra S, J. J. (2001). In situ bioremediation potential of an oily sludge-degrading bacterial consortium. *Curr Microbiol 1*, ;43(5):328–35.
Nilofar A, M. B. (2021). Waste from the petroleum industries as sustainable resource material in construction sectors; Opportunities, limitations and directions. *journal of Cleaner Production*, 125459.
Noria. (2023, April 17). *Machinery Lubrication*. Retrieved from machinerylubrication.com: http://www.machinerylubrication.com
Oil, E. (2002, June 4). *evergreenoil*. Retrieved from evergreenoil.com: http://www.evergreenoil.com
Pandey, P. &. (2015). *Research Methodology: Tools and Techniques.* Romania: Bridge center.
Programme, U. N. (n.d.). *wedocs.unep.org*. Retrieved from https://wedcos.unep.org.
Scribbr. (n.d.). *Scribbr.com*. Retrieved from www.scribber.com: https://www.scribber.com
Taulo.L., G. a. (2015). Energy Supply in Malawi. *Journal of Energy in Southern Africa*. Retrieved from CEIC: www.ceicdata.com
Teng Q, Z. D. (2021). A review of the application of different treatment processes for oily sludge. *Environ Sci Pollut Res* , 121–32.
Wahbeh.B. (2002, September). *Environmental Health and Safety*. Retrieved from Evergreen Oil.
Ward O, S. A. (2003). Accelerated biodegradation of petroleum hydrocarbon waste. *J Ind Microbiol Biotechnol*, ;30(5):260–70.
Wlodarczyk.P. (2022). Feasibility of Waste Engine Oil Electrooxidation with Ni-CO and Cu-B catalysts.
Zhang, J. (2012). Treatment of refinery oily sludge using ultrasound, bio-surfactant, and advanced oxidation processes.
Zhao, Y. (2017, August 30). *Municipal Solid Waste Management and Waste to Energy Possibilities in thePhilippines*. Retrieved from lutpub.lut.fi: https://lutpub.lut.fi/bitstream/handle/10024/136223/Yilin%20zhao-Master%20thesis