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Research Article

Attitudes and Environmental Awareness of Vehicle Service Technicians in Generating and Disposing of Waste Lubricant Oil in Ghana: Barriers to the Circular Economy

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Abstract

Inappropriate handling and disposal of waste lubricant oil (WLO) can lead to detrimental effects on soil and water matrices. Despite the documented economic and energy value of WLO, developing countries have not yet harnessed these opportunities due to a lack of information on quantities generated, perceived value, and infrastructure for collection, reuse, recycling, or disposal. In this study, the quantity of WLO generated and attitudes and environmental awareness of vehicle service technicians (n=329) were assessed in seven regions of Ghana. The mean volume of WLO generated was 35.6 L/shop/week, with southern urban suburbs generating more than their northern counterparts. Most (53%) technicians dispose of WLO by selling it, while 83.3% are aware that inappropriate disposal is detrimental to the environment. However, 10% discarded the WLO into sewers and soil. About two-thirds (63%) of vehicle service technicians are willing to use waste management services to dispose of WLO, but only 33% are willing to pay for such services. The study shows that closing the circular economy loop for the lubricant oil sector will have minimal barriers. Municipal waste management companies should invest in WLO collection infrastructure to help drive the circular economy of synthetic lubricating oils, reduce the fire hazard posed by improper WLO storage, educate technicians to eradicate soil and water contamination from poor waste oil handling and disposal practices, and safeguard ecosystem and human health in developing countries.

Keywords

Waste Lubricant Oil, Vehicle Technicians' Attitudes, Waste Quantification, Environmental Awareness, Circular Economy, Ghana

1. Introduction

Waste lubricant oil (WLO) is a hazardous waste with immense ecotoxicological potential and human health consequences if poorly managed. In the European Union, WLO ranked as the most voluminous hazardous waste generated, with an estimated 16 million tonnes produced per annum [1, 2]. In Africa, the leading economy in the generation of used lubricant

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oil, Alexandria in Egypt, discards 64% of the 1.4 × 10^5 tonnes of WLO annually into sewers, at the detriment of the environment [3]. The damaging impacts of WLO discharged into environmental systems include heavy metal pollution of soil [4], changes in soil quality and ecology [5], water pollution [6] (Parekh et al., 2024), food crops contamination with polyaromatic hydrocarbons [7] and several ecotoxicological and human health risks [8]. For example, the germination and seedling growth of lawn grass and tropical food crops were impeded by WLO-contaminated soil [9, 10]. Chromium, manganese, iron and zinc concentrations were higher in WLO-contaminated soil, resulting in elevated hazard quotients [11]. Furthermore, without adequate regulatory oversight, WLO has also been used for environmentally unfriendly purposes, such as fuel in bakeries, weed killer, dust suppressant on dusty roads and bare grounds, and for rust prevention on spare vehicle parts [12]. Not only are these uses greatly detrimental to the environment and ecosystems, but they also cause economic losses [13]. To prevent the environmental degradation caused by the inappropriate disposal or use of WLO, a circular economy approach, which seeks to eliminate waste through product life cycle analysis, co-designing and greener energy alternatives to close the loop on material flow [14], should be adopted.

Life cycle assessment (LCA) of spent/used lubricant oils demonstrates that effective management of WLO as a resource rather than waste yields superior economic, social and environmental outcomes, vis-à-vis discharging into environmental matrices [3]. Transforming the WLO to add value, a process known as valorisation, is highly recommended by circular economists and life cycle assessors [15]. Valorisation of WLO can be achieved through various approaches, but energy recovery and base oil regeneration are the two major pathways [16]. These pathways result in reduced soil and water degradation, lower greenhouse gas emissions [3], sustainable raw material usage, and increased revenue generation, while supporting Sustainable Development Goal (SDG) 12, which urges responsible consumption and production [17]. Nonetheless, effective collection, transportation and recycling of WLO to realise the full enviro-socio-economic benefits depend on up-to-date of location, frequency and quantity of the waste generated in the sector [18] and a well-trained workforce to handle the waste. But data on industrial waste is scanty, with no specific study on WLO generation.

For several decades, Ghana has been experiencing an upward economic growth from increased government-private sector spending [19], stimulating industrialisation, agricultural expansion, increased mineral extraction, higher employment rates and a rise in vehicle ownership [20]. These phenomena predict an upward trend of vehicle servicing and maintenance activities, and consequently rising levels of WLO generation. The management of WLO removed during the maintenance, inspections and repairs of commercial and private vehicles and heavy-duty machinery requires specialist services to safely handle and appropriately dispose of or recycle this hazardous waste. Managing waste with such high environmental risks requires clear policies, appropriate waste technologies, and well-trained personnel to support the sustainable development of cities [21]. Therefore, recovery and proper valorisation or disposal of WLO to eliminate the adverse environmental effects associated with this hazardous waste cannot be achieved without insights into data on vehicle servicing technicians' waste management attitudes and environmental risk awareness. In this study, the volume of WLO removed from vehicles during servicing in seven regions of Ghana was evaluated. The environmental awareness of vehicle technicians of the damage caused by the inappropriate disposal of WLO, access and willingness to patronise waste management services for the disposal of WLO, and their current method of disposing of waste oil were also assessed. Insights from this study will inform planning, collection and recycling of WLO. The findings will also enable regulators to formulate functional policies, devise training/educational interventions for vehicle technicians to improve WLO collection and valorisation.

2. Materials and Methods

2.1. Description of the Study Area

This mixed-methods cross-sectional study was conducted in seven of the sixteen regions in the Republic of Ghana, situated on the coast of the Gulf of Guinea in Western Africa. The country is bordered to the North by Burkina Faso, East by Togo, South by the Atlantic Ocean and West by Côte d'Ivoire, with a total land area of 238,540 km^2. The geographic coordinates of the land lie between 800N latitude and 200W longitude and hold about 31 million inhabitants [22]. The cities and towns in the country have makeshift conglomerates of vehicle maintenance shops, such as Abossey-Okai in Accra, Suame Magazine in Kumasi and Kokompe in Takoradi, where engine and gearbox oil changes are conducted regularly for commercial and private vehicles [23]. Often, these vehicle maintenance and service premises do not have concrete flooring with facilities to collect and treat oil spillages, leaving soil to absorb spilt oils.

2.2. Sample Size, Locations and Collection

A convenience sampling approach was employed to engage mechanics at vehicle servicing workshops in the suburbs of seven regions in Ghana. The survey was conducted in the regions of Greater Accra (Adenta, Tema Communities 1, 2 and 3, Gbawe, Oyarefa), Ashanti (Abrepo, Emina, Suame Magazine, Ohwim, Obuasi - Nyameso), Central (Cape Coast - Ayensudo, Assin Fosu), Eastern (Nkawkaw), Western (Kokompe -Takoradi), Western North (Sefwi Wiawso) and Upper West (Wa), shown in Figure 1. At each vehicle maintenance shop, informed consent was obtained from the lead service technician to participate in a week-long study where they saved all the waste lubricant oil removed from vehicle engines or gearboxes for the research team to measure the following week. After six working days, the research student returned to

the workshop to measure the quantity of WLO collected. A total of 329 vehicle service stations in 17 districts and towns in 7 regions were assessed for the amount of WLO generated weekly.

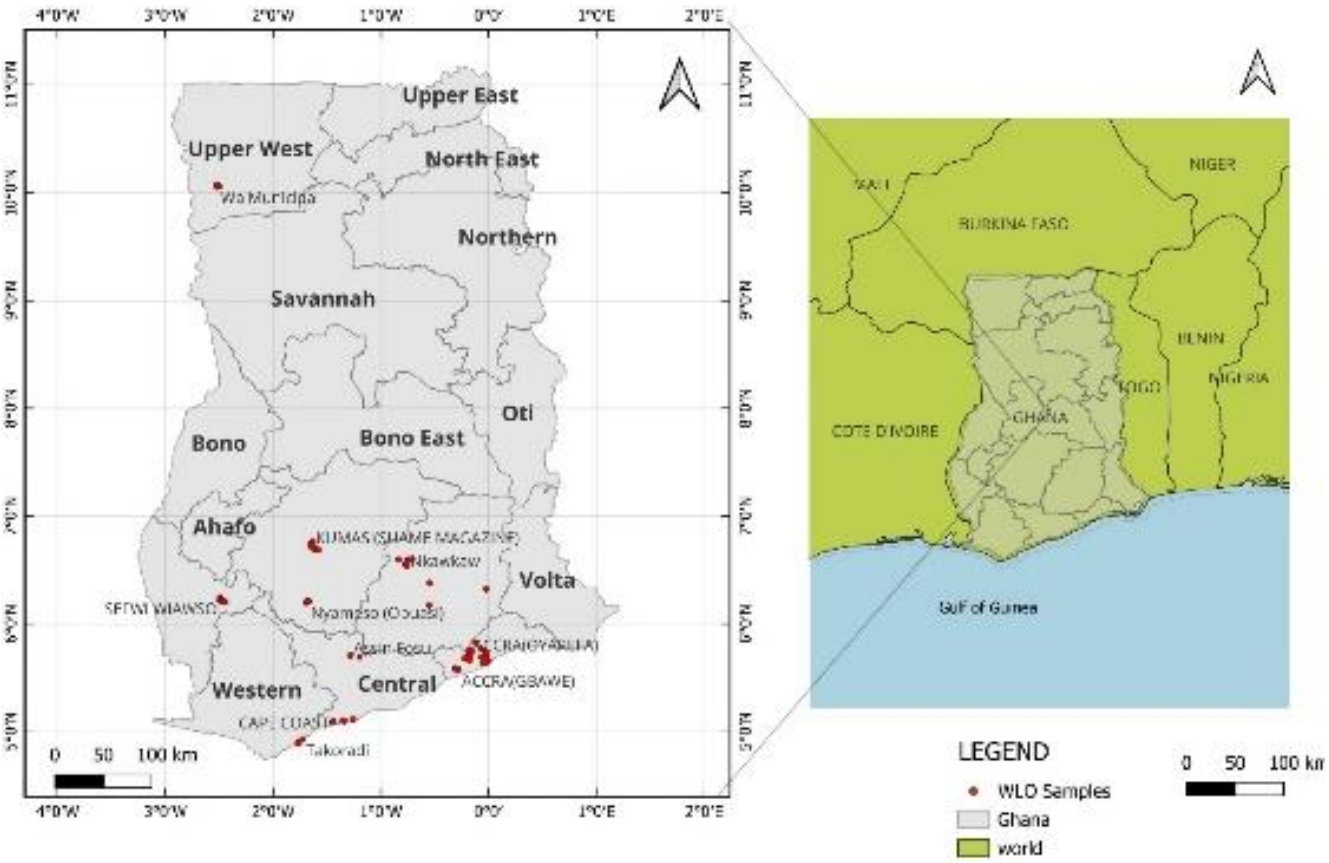

Figure 1. *Location of vehicle service stations where waste lubricant oil was quantified.*

2.3. Quantification of Waste Lubricant Oil at Vehicle Maintenance Shops in Ghana

The volume of the WLO stored at the vehicle servicing station was measured by transferring the oil in the storage drum into a graduated 5 L Lube Oil container, which was subsequently poured into an empty drum and tallied. This method was repeated until the entire volume of WLO in the storage drum had been transferred and quantified. Appropriate personal protective equipment, including goggles, face masks, gloves, safety shoes, and protective clothing, was donned before handling the WLO.

2.4. Questionnaire Administration

A questionnaire was also completed with a senior vehicle technician at each sampled location. Demographic characteristics of the technicians, their method of disposal for WLO, access to MWMS and willingness to pay for such a service, as well as their environmental awareness of the consequences of improper disposal of WLO, were collected through the research instrument.

2.5. Ethical Approval and Consent to Participate Declaration

The methodology and the questionnaire for the study received ethical approval (HuSSREC/AP/279/VOL.4) from the Humanities and Social Science Research Ethics Committee at the Kwame Nkrumah University of Science and Technology (KNUST) before engaging with the participants. On each visit to the vehicle service technicians, informed consent was obtained from the participants, conforming to the ethical clearance requirements and the KNUST research ethics policy. Data collected did not include personally identifiable information, and participants were informed of their right to withdraw from the study if they wished to do so.

2.6. Data Analysis

The responses from the administered questionnaires were processed using the Statistical Package for Social Sciences software version 20 to generate descriptive statistics of the amount of WLO produced and the heavy metal content in the soil samples. Inferential statistics were also conducted on the

responses to extrapolate and establish the correlations and associations between demographic characteristics of participants and their views on environmental impacts from their occupation and waste management preferences.

3. Results and Discussion

3.1. Amount of Waste Lubricant Oil Generated in Selected Regions of Ghana

The mean volume of WLO measured at vehicle service stations in Ghana was 35.6 L per week (Figure 2). The range of WLO in the study shops was between 1.2 L and 225 L per week. It was observed that highly populated urban towns and cities generated more WLO, with the highest found at Suame Magazine, an established area for vehicle maintenance, servicing and repairs in the country. To reduce the occurrences of WLO contamination of soil and water, high-generation areas where production exceeds the national average per week per shop should have designated tanker trucks for the WLO collection from the source to the refinery. These areas include Suame Magazine (108.5 L/w/shop), Abrepo (57.4 L/w/shop), Oyarefa (49.3 L/w/shop), Gbawe (35.5 L/w/shop) and Kokompe in Takoradi (66.5 L/w/shop), shown in Figure 2.

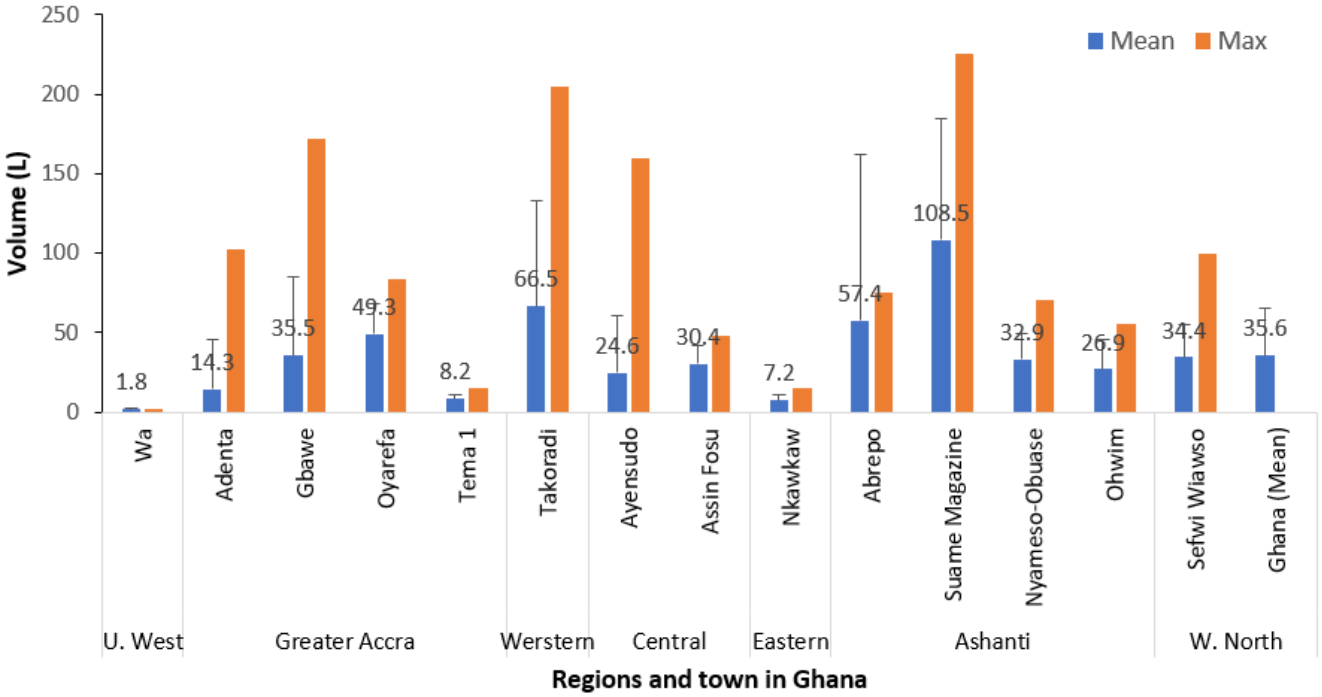

Figure 2. *Waste lubricant oil generated at vehicle maintenance shops in regions and suburbs of Ghana.*

3.2. Demographic Characteristics of Respondents

The vehicle service mechanics predominantly involved in the generation and handling of waste lubricant oil are mostly male (96.7%), aged below 40 years (77.8%), and have attained basic (40.4%) or secondary (44.7%) education (Table 1). Approximately one-third (78.4%) of the service station mechanics are highly experienced, with more than five years in the business. The male dominance in the sector is confirmed by [24]. The laborious and exhaustive nature of this work may explain why females rarely engage in vehicle repairs, as observed by [25]. In most African countries, females work in physically less demanding jobs, such as dressmaking [18], whereas work involving manual handling is often done by males [26]. The age distribution of the vehicle servicing technicians is comparable to findings by [27]. The low representation of technicians over 60 years may be attributed to the strenuous nature of the job, often requiring mechanics to work in hot weather for long periods, mostly carrying heavy loads, which may be difficult for technicians over 60 years. Furthermore, the Retirement age for men in Ghana is 60 years, and therefore, shop owners above this age work more in supervisory/management roles in the auto industry, as there is no state pension for non-government retirees. Among the respondents, 40.4% had completed basic education, 44.7% had completed senior high, and only a small fraction had completed tertiary or had no formal education. In Ghana, tertiary education is a significant financial burden for most families, and therefore, individuals seeking to work in apprentice-related careers often do not attain third-cycle education. This trend in the level of education among vehicle service mechanics is similar to that

among fashion designers [18]. Others also decide to drop out of school, as mechanics who are recruited at a very tender age grow into it and master its skills much earlier [27]. Since most of the respondents were young, it confirms the results obtained on their years of experience, as the majority (35.6%) of them had 5 - 10 years of experience. The mechanic shops under study were more populated in the urban cities of Greater Accra and Ashanti regions than the rural cities of the other regions. This could be because it is assumed that urban cities open more opportunities to make wealth as they hold larger populations and hence more vehicles to service [28].

3.3. Disposal Preferences and Environmental Awareness of Vehicle Service Technicians

The method of WLO disposal used by respondents ranged from selling (52.9%) to collection by traders or WMS (32.2%), pouring into drains or on the ground (10.3%), and reuse or recycling (1.2%), as depicted in Table 1. This distribution is consistent with waste-disposal practices observed among secondhand clothing sellers in the Kumasi Metropolis, where rejected clothing from bale sorting was valued and often sold [18]. The fraction of respondents who dispose of WLO inappropriately by pouring it into drains (10.3%) is comparable to those unaware that it is detrimental to the environment (16.7%) (Table 1). WLO discarded into drains and gutters forms an oil film on water surfaces that obstructs sunlight from reaching aquatic plants, making it difficult for photosynthesis to occur. This oil film also prevents oxygen diffusion into the water, restricting the respiration of fish. The oil layer also increases the BOD, leading to further depletion of dissolved oxygen in the water and suffocation of fish [29]. The toxic substances, including polyaromatic hydrocarbons and heavy metals, in the WLO may also kill aquatic primary consumers that support the food chain [30]. In Ghana, it is typical for rural dwellers to rely on streams and rivers for cooking, bathing, washing, and sometimes drinking [22]. Downstream users of WLO-contaminated waterbodies may suffer health consequences [30].

The proportion of respondents who sold their WLO in this study (52.9%) is also similar to the observations elsewhere [31]. Most (83.3%) of the respondents were aware that inappropriate disposal of WLO has adverse environmental impacts (Table 1), a finding that correlated with respondents' educational attainment (Table 2). Most (63.8%) service technicians expressed interest in using municipal waste management service (WMS) to reduce the environmental hazards, if the service were provided. Nevertheless, 67.2% of the study sample were unwilling to pay for such services. This may be due to the profit from selling the WLO, causing them to be reluctant to patronise another alternative, even though they recognise the environmental benefit of WMS in handling this hazardous waste correctly. Technicians' willingness to pay for WMS for the collection and disposal of WLO was also found to correlate with their age (Table 2), whilst their attitudes toward WLO disposal also correlated with their disposition to use WMS if available (Table 3).

Table 1. *Sociodemographic characteristics, waste management practices and environmental awareness of respondents.*

Demographics and perceptions	Options to question	Frequency	Percentage
Gender	Female	11	3.3
	Male	318	96.7
Age	18 - 25	57	17.3
	26 - 30	91	27.7
	31 - 40	108	32.8
	41 - 50	53	16.1
	51 - 60	19	5.8
	>60	1	0.3
Educational level attained	No formal education	133	40.4
	Basic	28	8.5
	Secondary	147	44.7
	Tertiary	21	6.4
Years of experience as a service technician	< 5 years	71	21.6
	5 - 15 years	188	57.1
	>15 years	70	21.3

Demographics and perceptions	Options to question	Frequency	Percentage
How do you dispose of your waste lubricant oil?	Collected by MWS	28	8.5
	Collected by traders	78	23.7
	Poured into drains or on the ground	34	10.3
	Recycle/reuse	4	1.2
	Sell	174	52.9
	Other	11	3.3
Does the inappropriate disposal of WLO damage the environment?	Yes	274	83.3
	No	55	16.7
Are you willing to use MWMS for oil disposal	Yes	210	63.8
	No	119	36.2
Are you willing to pay for MWMS to collect the waste oil	Yes	108	32.8
	No	221	67.2

Table 2. *Correlation of respondents' sociodemographic variables with their waste management preferences and environmental awareness.*

Demographics of respondents		How do you dispose of your WLO?	Does inappropriate WLO disposal damage the environment?	Would you use MWMS if it were available?	Would you pay for such a service?
GENDER	Pearson corr. coeff.	.114*	-.038	.001	-.086
	Sig. (2-tailed)	.039	.492	.989	.119
	N	329	329	329	329
AGE	Pearson corr. coeff.	-.096	.046	-.141*	-.284**
	Sig. (2-tailed)	.081	.401	.011	.000
	N	329	329	329	329
EDUCATION	Pearson corr. coeff.	-.066	.113*	.056	.066
	Sig. (2-tailed)	.232	.041	.308	.231
	N	329	329	329	329
YEARS OF EXPERIENCE	Pearson corr. coeff.	-.075	-.119*	.046	.072
	Sig. (2-tailed)	.176	.032	.407	.193
	N	329	329	329	329

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).

Table 3. *Correlation between participants' waste management practices and their environmental awareness.*

		Would you use MWMS if it were available?	Would you pay for MWMS to dispose of your waste oil?
How do you dispose of your waste oil?	Pearson Correlation	-.151**	-.100
	Sig. (2-tailed)	.006	.070
	N	329	329

		Would you use MWMS if it were available?	Would you pay for MWMS to dispose of your waste oil?
Does inappropriate waste oil disposal damage the environment?	Pearson Correlation	-.015	-.034
	Sig. (2-tailed)	.784	.542
	N	329	329

**. Correlation is significant at the 0.01 level (2-tailed). The correlation coefficients were interpreted as negligible (0.00-0.09), weak (0.10-0.39), moderate (0.40-0.69), strong (0.70-0.89), and very strong (0.90-1.00), as described by Schober and Schwarte (2018).

3.4. Implications: Opportunities and Threats

Currently, there are approximately 3 million registered vehicles in Ghana, estimated based on the 2.1 million registered vehicles in 2017 [32] and the one million vehicles imported each decade [33]. On average, private vehicles in Ghana cover 14,000 miles annually, higher than most European personal cars [32, 34]. Based on the recommended frequency for engine oil change after every 5000 to 10000 miles, from Toyota RAV4 models 2013 to 2022 manuals and a survey of drivers' attitudes in Europe [35, 36], while factoring in the age of the vehicle, poor road conditions, dust and traffic jams, vehicles' engine oil may be changed three times each year in the country. Using an average engine oil sump capacity of 4.5 L for a 1.5 to 2 dm^3 engine [36], an estimated 40.5 million litres of WLO would be removed by vehicle servicing technicians.

Through effective waste management practices, the estimated WLO could be recycled into base oil for the production of engine oil [3] or burnt as fuel to provide energy for electricity generation, capturing the carbon dioxide emitted [37], serving as a major resource for the energy and oil manufacturing sector and closing the circular economy loop [1]. With many African countries, such as Nigeria and Ghana, struggling to generate adequate electrical energy to meet domestic and industrial needs [38, 39], effective collection and reuse of WLO in power stations could serve small communities or vital institutions, such as hospitals, during load shedding, increasing the nation's energy security and productivity. Alternatively, recycling the 40.5 million litres of WLO generated per annum in the country could produce up to 36% yield of base oil [40], reducing the need for crude oil extraction (new resources) for base oil production [41].

However, failure to collect and appropriately valorise the 40.5 ML of WLO, a hazardous waste containing heavy metals [4] and PAHs [7], poses a significant risk to water and soil contamination from WLO disposal practices. Improper disposal and unfriendly uses of the waste oil may result in severe ecological and human health risks from WLO entering the Ghanaian environment,

4. Conclusion

This research assessed the volume of waste lubricant oil generated in vehicle maintenance shops, vehicle technicians' demographics, attitudes to waste disposal, awareness of environmental impacts, willingness to patronise and access to waste management services. The volume of WLO oil generated per shop is 35.6 L/week. Most vehicle service technicians are males (97%), formally educated (60%), and recognise that inappropriate WLO disposal is detrimental to the environment (83.3%). The majority dispose of WLO by selling (53%), but 10% pour it into drains, gutters or soil. 63% of vehicle service technicians are willing to pay for waste management services, which correlated with their age and disposal method. The study findings show that waste management companies should invest in the collection, recycling and disposal of this hazardous waste. The Ghana Environmental Protection Authority should educate and train vehicle technicians, improve monitoring of premises and enforce the guidelines to protect soil and water bodies in the country.

Abbreviations

LCA	Life Cycle Assessment
SDG	Sustainable Development Goal
WLOO	Waste Lubricant Oil
WMS	Waste Management Services
MWMSM	Municipal Waste Management Services

Author Contributions

Lawson Mensah: Conceptualization, Resources, Supervision, Writing – original draft

Nahima Mahama: Formal Analysis, Methodology, Data curation

Gideon Nkrumah: Data curation, Validation, Visualization

Bright Kwaku Agbekey: Methodology, Supervision, Data curation, Formal analysis

Evans Kwarteng: Conceptualization, Writing – review & editing, Data analysis

Ethel Bentil: Supervision, Writing – original draft

Lina Appiah-Nuamah: Data curation, Methodology, Writing – review & editing

Data Availability Statement

All the data supporting the findings of this study are included in the manuscript.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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