REVISTA CONTRIBUCIONES A LAS CIENCIAS SOCIALES

Management of used lubricating oils in mechanical workshops: a case study in Mozambique

Gestão de óleos lubrificantes usados em oficinas mecânicas: um estudo de caso em Moçambique

Gestión de aceites lubricantes usados en talleres mecánicos: un estudio de caso en Mozambique

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ABSTRACT
Environmental problems are related to unsustainable practices, often adopted without due awareness of their impacts. Frequently, society's reaction is late, occurring after evident signs of environmental degradation. Among the various sectors that can contribute to this situation, service stations and mechanical workshops stand out, whose activities can release pollutants into the environment. One of the main wastes generated in these places is used lubricating oil from vehicle engines, which, after its use, becomes a hazardous waste due to its high potential for environmental contamination and risks to public health; therefore, it requires proper and regulated management. This study aimed to analyze the management of used lubricating oils extracted from motor vehicles in workshops in the city of Quelimane, Zambézia province, Mozambique. Thus, 35 workshops were analyzed, with the participation of those responsible for the lubrication area in each one. Data were obtained through interviews and direct observation, characterizing a qualitative approach to understand perceptions, practices, behaviors, and environmental contexts in the city. Six criteria were categorized and studied, and a descriptive analysis was performed to interpret the results. The study showed that all the workshops analyzed face environmental and social conflicts, in addition to improperly disposing of used lubricating oil. The methodology adopted in this study can support decision-making, highlighting the importance of raising awareness among those involved and the community for compliance with environmental legislation and the preservation of public health.

Keywords: environment, vehicle engines, public health, awareness.

RESUMO
Os problemas ambientais estão relacionados a práticas insustentáveis, muitas vezes adotadas sem a devida consciência de seus impactos. Frequentemente, a reação da sociedade ocorre de forma tardia, após os sinais evidentes da degradação ambiental. Entre os diversos setores que podem contribuir para essa situação, destacam-se as estações de serviço e oficinas mecânicas, cujas atividades, podem liberar poluentes no meio ambiente. Um dos principais resíduos gerados nesses locais é o óleo lubrificante usado, proveniente dos motores de veículos, que após sua

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utilização, torna-se um resíduo perigoso pelo seu elevado potencial de contaminação ambiental e riscos à saúde pública; exigindo, portanto, um manejo adequado e regulamentado. O estudo teve como objetivo analisar a gestão dos óleos lubrificantes usados, extraídos dos veículos automotores nas oficinas da cidade de Quelimane, província da Zambézia, Moçambique. Assim, foram analisadas 35 oficinas, com a participação dos responsáveis pela área de lubrificação em cada uma delas. Os dados foram obtidos por meio de entrevistas e observação direta, caracterizando uma abordagem qualitativa para compreender percepções, práticas, comportamentos e contextos ambientais na cidade. Foram categorizados seis critérios estudados e feita a análise descritiva para interpretação dos resultados. O estudo mostrou que todas as oficinas analisadas enfrentam conflitos de natureza ambiental e social, além de destinarem de forma inadequada o óleo lubrificante usado. A metodologia adotada neste estudo pode subsidiar a tomada de decisões, ressaltando a importância da conscientização dos envolvidos e da comunidade para o cumprimento da legislação ambiental e a preservação da saúde pública.

Palavras-chave: meio ambiente, motores de veículos, saúde pública, consciencialização.

RESUMEN

Los problemas ambientales están relacionados con prácticas insostenibles, a menudo adoptadas sin la debida conciencia de sus impactos. Con frecuencia, la reacción de la sociedad es tardía, produciéndose tras evidentes signos de degradación ambiental. Entre los diversos sectores que pueden contribuir a esta situación, destacan las estaciones de servicio y los talleres mecánicos, cuyas actividades pueden liberar contaminantes al medio ambiente. Uno de los principales residuos generados en estos lugares es el aceite lubricante usado de los motores de vehículos, que, tras su uso, se convierte en un residuo peligroso debido a su alto potencial de contaminación ambiental y los riesgos para la salud pública; por lo tanto, requiere una gestión adecuada y regulada. Este estudio tuvo como objetivo analizar la gestión de los aceites lubricantes usados extraídos de vehículos de motor en talleres de la ciudad de Quelimane, provincia de Zambézia, Mozambique. Para ello, se analizaron 35 talleres, con la participación de los responsables del área de lubricación en cada uno. Los datos se obtuvieron mediante entrevistas y observación directa, caracterizando un enfoque cualitativo para comprender las percepciones, prácticas, comportamientos y contextos ambientales en la ciudad. Se categorizaron y estudiaron seis criterios, y se realizó un análisis descriptivo para interpretar los resultados. El estudio demostró que todos los talleres analizados presentan conflictos ambientales y sociales, además de una gestión inadecuada del aceite lubricante usado. La metodología empleada puede servir de base para la toma de decisiones, al tiempo que subraya la importancia de sensibilizar a las personas implicadas y a la comunidad sobre el cumplimiento de la legislación ambiental y la preservación de la salud pública.

Palabras clave: medio ambiente, motores de vehículos, salud pública, concienciación.

1 INTRODUCTION

The intensification of industrialization and consumption has accelerated environmental degradation, resulting in increased air, water, and soil pollution (Mendonça, 2022; Espíndola; Ribeiro, 2020; Campos; Biudaro, 2025). As highlighted by Beaud, Beaud, and Bouguerra (1995) and Albuquerque (2007), these impacts stem from an unsustainable production model grounded in the continuous exploitation of natural resources.

Among the relevant pollution sources are mechanical workshops and fuel stations, which often generate environmental liabilities associated with spills of lubricating oils (LO). When improperly handled, these oils can pose serious risks to both the environment and public health (Moisa; Kaskantzis, 2005; Oliveira *et al*., 2025). Used lubricating oil (ULO) – a residue formed as lubricants degrade – contains heavy metals and toxic compounds. If disposed of incorrectly, it contaminates soil and groundwater and is therefore classified as a hazardous waste (El-Fadel; Khoury, 2001; Willing, 2001; Mazalli, 2010; Environmental Protection Association of Cianorte – APROMAC, 2011).

Environmental management aligned with the Sustainable Development Goals and the United Nations' 2030 Agenda calls for sustainable practices in automotive activities, including the proper collection, storage, and disposal of ULO. In Quelimane, however, the disposal practices adopted by mechanical workshops fall short of current Mozambican legislation, which still lacks specific mechanisms to support reuse and to integrate selective collection and recycling organizations into the municipal waste management system. This gap hinders both poverty reduction efforts and the mitigation of environmental impacts (Manuel, 2013; Manuel, 2025).

Therefore, this study aimed to assess ULO management in mechanical workshops and fuel stations in the city of Quelimane, Zambézia Province, Mozambique, focusing on structural conditions, handling practices, and the relationship between workshop categories and years of operation.

2 THEORETICAL FRAMEWORK

Used lubricating oil (ULO), a waste product generated from the degradation of lubricating oils (LO) after their use in engines and mechanical systems, poses a serious environmental threat when not properly collected and disposed of. Even when there is no intentional discharge, ULO can return to the environment through small, often unnoticed leaks, eventually reaching rivers that flow into the ocean (Gonzaga, Silva; Andrade, 2021).

ULO can be extracted from a wide range of motorised equipment, including cars, trucks, motorcycles, boats, trains, aeroplanes, and tractors, as well as chainsaws, designed for various purposes and configurations. All these machines share a common characteristic: they depend on engine lubrication to function properly (APROMAC, 2011).

According to the APROMAC (2011), used lubricating oil – often incorrectly referred to as "burnt oil," a discouraged and technically inaccurate term – is classified as hazardous waste immediately after it is drained from an engine or similar equipment. This classification is attributed to its toxicity and high potential to cause environmental and public health impacts (Manuel, 2013). Studies indicate that just one liter of ULO can contaminate up to one million liters of water, and it may take as long as 300 years to fully degrade. Furthermore, the direct burning of used lubricants without pre-treatment is subject to environmental restrictions, as these oils may contain toxic and hazardous substances (El-Fadel; Khoury, 2001; Willing, 2001; Mazalli, 2010).

This waste is classified as hazardous in several countries (APROMAC, 2011), and according to Mozambique's Waste Management Regulation (Decree No. 13/2006 of June 15), used lubricating oil is formally considered hazardous waste. The decree defines hazardous waste as any waste that presents characteristics such as flammability, explosiveness, corrosiveness, toxicity, infectivity, or radioactivity, or any other condition that may pose risks to human life, human health, other organisms, or environmental quality (Mozambique, 2006).

Few people are aware of the risks that improper ULO management poses to the environment and public health. According to APROMAC (2011), ULO has been used in inappropriate and dangerous ways in many contexts. In Brazil, for example, there are records of its use in veterinary procedures. Such traditional practices, common in socioeconomically disadvantaged groups, overlook both environmental risks and the potential harmful effects on human and animal health. In Quelimane, ULO is used for floor waterproofing, surface sealing, wood treatment against insects and fungi, and even in informal medicinal applications for dermatological conditions.

Lubricating oils are generally sold at service stations or fuel supply posts and, during preventive maintenance, used oil is replaced with new oil (Manuel, 2013). In some cases, LO is sold in appropriate containers together with other products in various commercial settings (Cipriano, 2017). This allows individuals to purchase oil and replace it themselves either fully substituting the ULO or simply topping up the existing oil in the engine outside formal service stations (Manuel, 2013).

Waste management within these business segments is therefore critical, given that their activities pose significant environmental hazards due to their close interaction with groundwater, soil, and air. In the event of accidents, these interactions can compromise the quality of both surface and groundwater, leading to severe environmental impacts, harming local fauna and flora, and ultimately posing risks to public health (Lorenzett; Rossato, 2010; Silva *et al.*, 2025).

As a developing country, Mozambique's petroleum products market is dominated by several national and international companies, such as BP, Petromoc, Shell, Mobil, Total, Engen, Galp, and Caltex. Among the products sold, lubricating oil (LO) is notable. It is estimated that the country consumes around 8,500 tonnes of lubricants annually, of which approximately 5,000 tonnes (60%) become used lubricating oil (ULO). The remaining 40% corresponds to consumption during use, mainly through combustion and mechanical losses. However, data on the collection of this hazardous waste remain scarce, suggesting that a large portion of ULO may be disposed of directly into soil or the sea without any proper treatment, posing environmental and public health risks (Manuel, 2013).

In general, fuel service stations carry out activities such as fuel storage and sales, vehicle washing and refueling, oil and filter changes, lubrication services, operation of convenience stores, and treatment of generated liquid effluents (Rocha *et al.*, 2014; Crizel; Lara, 2020). Mechanical workshops, in turn, provide basic services such as oil changes, routine inspections and preventive maintenance, sale of accessories, and simple repairs tailored to the type of service and clientele (Dalçóquio, 2007). For the purposes of this study, all establishments that performed oil changes were classified as workshops.

3 METHODOLOGY

3.1 STUDY AREA

The study was conducted in the city of Quelimane, located in Zambézia Province, Mozambique, at 17°52′42″S latitude and 36°53′17″E longitude. According to the Köppen–Geiger climate classification, the region has an Aw climate (tropical savanna with a dry winter)

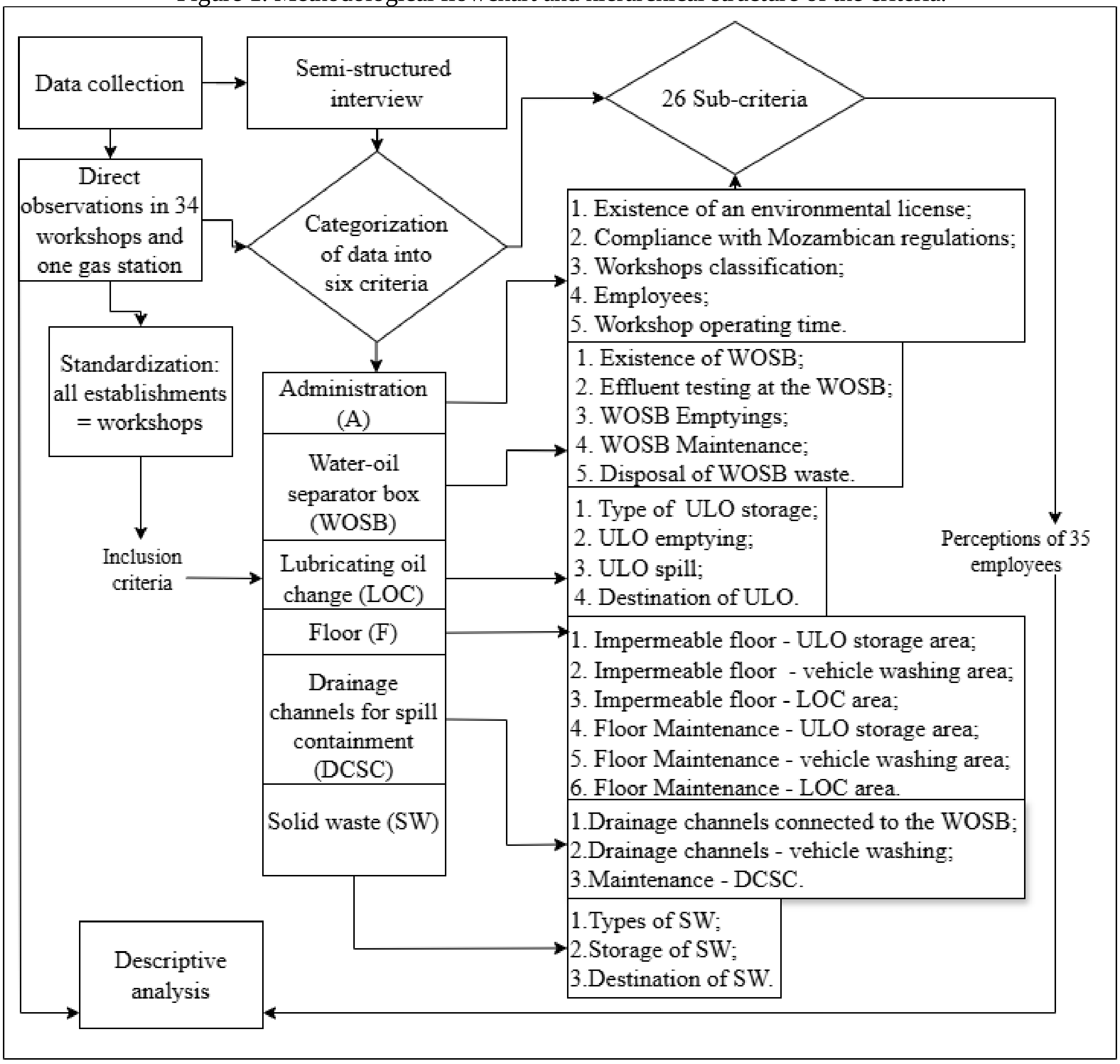
(Peel, Finlayson; McMahon, 2007), with an average annual temperature of 25.6 °C. Quelimane is situated approximately 1,600 km north of Maputo, the country's capital, and covers an area of about 117 km² (Ministry of State Administration and Public Service – MAEFP, 2020; National Institute of Statistics – INE, 2024).

3.2 METHODOLOGICAL PROCEDURES

The methodological procedures adopted (Figure 1) allowed the data to be organized and categorized within a hierarchical structure, establishing subordinate relationships between criteria and sub-criteria. The flowchart illustrates the methodological path adopted in the study, beginning with data collection through direct observations and semi-structured interviews conducted in 34 workshops and one gas station, all standardized in workshops to facilitate data processing. The six main categorized criteria were: administration (A), water and oil separator box (WOSB), lubricant oil change (LOC), floor (F), spill containment drainage channels (DCSC), and solid waste (RS), which together gave rise to 26 specific sub-criteria.

Finally, both the perceptions of the 35 workers and the field observations were treated through descriptive analysis, following the approach proposed by Silva and Oliveira (2011), which allowed the results to be interpreted considering the practices and conditions associated with the management of OLU in the Quelimane workshops.

Figure 1. Methodological flowchart and hierarchical structure of the criteria.



Source: Prepared by the authors.

4 RESULTS AND DISCUSSIONS

4.1 RESULTS

Table 1. Data on the criteria analyzed and sub-criteria derived from field observations and interview responses

Criterion	Sub-criterion	Characteristic	Frequency	%
Administration (A)	Existence of an environmental license	Yes	35	100
	Compliance with Mozambican regulations	No	35	100
	Workshop Classification	Classe A	2	5,7
		Classe B	6	17,1
		Classe C	27	77,1
	Employees	Basic training	35	100

		Use of basic equipment	17	48,6
		No basic equipment	18	51,4
	Workshop operating time	0 – 5 years	27	77,1
		6 – 10 years	6	17,1
		11 – 15 years	2	5,7
Oil and Water Separator (WOSB)	Existence of WOSB	Yes	3	8,6
		No	32	91,4
	Effluent testing at the WOSB	No	35	100
	WOSB Emptyings	Yes	2	5,7
		No	1	2,9
		Without OWS	32	91.4
	WOSB Maintenance	Yes	1	2,9
		No	2	5,7
		Without OWS	32	91.4
	Destination of OWS waste	Inadequate	3	8,6
		Without OWS	32	91,4
Lubricating oil change (LOC)	Type of ULO storage	Drums	24	68,6
		Other containers	11	31,4
	ULO emptying	Yes	26	74,3
		No	9	25,7
	ULO spill	Yes	26	74,3
		No	9	25,7
	Destination of ULO	Inadequate	35	100
Flooring (F)	Impermeable floor in the ULO storage area	Yes	1	2,9
		No	34	97,1
	Impermeable floor in the vehicle washing area	Yes	1	2,9
		No	34	97,1
	Impermeable floor in the LOC area	Yes	1	2,9
		No	34	97,1
	Floor maintenance (ULO storage area)	Yes	1	2,9
		No	34	97,1
	Floor maintenance (vehicle washing area)	Yes	1	2,9
		No	34	97,1
	Floor maintenance (LOC area)	Yes	1	2,9
		No	34	97,1
Drainage channels for spill containment (DCSC)	Drainage channels connected to the (WOSB)	Yes	2	5,7
		No	33	94,3
	Drainage channels (vehicle washing area)	Yes	5	14,3
		No	30	85,7
	Maintenance of the DCSC	Yes	2	5,7
		No	33	94,3
Solid waste (SW)	Types of SW	ULO equipment	35	100
	Storage of SW	Inadequate	35	100
	Destination of SW	Inadequate	35	100

Source: Prepared by the authors.

4.2 DISCUSSIONS

The discussion of results aimed to interpret and connect the collected data with the theoretical framework and existing legislation, seeking to understand the extent to which the practices observed in workshops in the city of Quelimane reflect compliance with Mozambican environmental standards. The analyses presented below not only describe the empirical findings but also highlight the legal, environmental, and social implications associated with the management of used lubricating oil (ULO) and workplace safety, as defined in national policies and related studies.

4.2.1 Administrative criterion (A)

Within the administrative criterion (Table 1), regulatory frameworks governing workshop activities in Mozambique were identified. The management of used lubricating oil (ULO) is addressed specifically in several countries that have advanced in discussions on the proper disposal of hazardous waste (Canchumani, 2013; Mendes, 2020). In Mozambique, the Environmental Law No. 20/1997 of 1 October forms the legal foundation of environmental policy, making the issuance of an environmental license mandatory for any activity with potential environmental impact (Mozambique, 1997; Fortes; Alfândega, 2022). This license is granted by the Ministry of Land, Environment and Rural Development (MITADER), contingent upon a prior Environmental Impact Assessment (EIA).

The main environmental regulations applicable to ULO management include Decree No. 54/2015 of December (Environmental Impact Assessment), Decree No. 56/2010a of 22 November (Petroleum Operations), Decree No. /2010b of 31 December (Environmental Quality Standards and Effluent Emission), Decree No. 25/2011 of 15 June (Environmental Audit Procedures), and Decree No. 83/2014 (Hazardous Waste Management). The latter sets standards for the production and management of hazardous waste and classifies both ULO and contaminated packaging as hazardous (Mozambique, 2010a, 2010b 2011, 2014, 2015). Despite the existing legal framework, the workshops do not fully comply with environmental regulations, as they fail to meet all established requirements. Although some administrative aspects show progress, these remain insufficient to ensure full compliance.

The classification of workshops, based on workers' perceptions of structural conditions and services offered, grouped the establishments into classes A, B, and C. Classes A (5.7%) and B (17.1%) provide more diversified services, while class C (77.1%) focuses on basic activities such as lubrication, painting, and bodywork. Simple structures and limited services predominate, with lubricating oil changes being the only service common to all workshops, underscoring its operational relevance in the local sector.

Regarding occupational safety, the use of personal protective equipment (PPE) showed an almost even distribution: 48.6% of workshops use some form of protection, while 51.4% operate without any PPE. This scenario reveals weaknesses in administrative management and non-compliance with occupational safety regulations, linked to limited oversight, scarce resources, and lack of technical training. The use of PPE is recognized as a primary barrier against harmful agents (Brazil, 2010), and its mandatory nature is established in Decree No. 83/2014 of 31 December, which requires proof of the availability of such equipment and the implementation of occupational health plans for workers exposed to hazardous waste (Mozambique, 2014).

Reports indicate a lack of formal training within the workshops, where learning occurs mainly through empirical, hands-on experience and daily practice. Although this informal knowledge transfer may be functional, it compromises technical standardization and regulatory compliance (Ferreira, 2016). The same decree (No. 83/2014 of 31 December) assigns workshop owners or managers the responsibility to train and protect workers, preventing accidents and occupational illnesses (Mozambique, 2014).

Continuous exposure to ULO can cause toxic and degenerative effects on human health, including tumor development and fetal malformation (APROMAC, 2011; Amarante; Alva, 2018). Thus, the lack of PPE and proper training contradicts Mozambican legislation (Law No. 13/2023 of 25 August – Labour Law), which reinforces the need for preventive measures (Mozambique, 2023).

Finally, it was observed that 77.1% of the workshops have been operating for up to five years, indicating not only that they are recent, but also that the sector is expanding, driven by the increase in vehicle numbers and demand for automotive services (Table 1). This growth strengthens the importance of adopting sustainable and quality administrative practices, ensuring business continuity and environmental compliance (Quinhões Pinto *et al.*, 2014).

4.2.2 Water–oil separator box (WOSB) criterion

According to the literature, the water – oil separator box (WOSB) plays a key role in containing oily effluents, preventing contaminated water from being discharged directly onto the ground and causing environmental impacts (Ucker *et al*., 2023). However, in this study, it was found that this equipment is rarely used in the evaluated workshops (Table 1), which compromises adherence to good environmental practices and current legal requirements.

Data showed that only three workshops (8.6%) had a WOSB, and effluent separation occurred in only one of them. The absence of this equipment in most workshops (91.4%) indicates non-compliance with environmental regulations, as it facilitates the direct discharge of water mixed with oil into the environment. Although Mozambique does not yet have specific regulations regarding WOSBs, Decree No. 83/2014 of 31 December states that wastewater generated by washing equipment and vehicles must be treated before disposal, reinforcing the responsibility of businesses in managing oily residues properly (Mozambique, 2014).

From a technical perspective, water–oil separators—typically installed in conjunction with sand traps, are devices designed to remove solid waste and free oil from effluents generated during vehicle and equipment washing (Secron; Giordano; Barbosa Filho, 2006). The literature recommends periodic effluent testing to ensure that oil concentrations remain within legal limits; in Mozambique, the maximum permissible level is 10 mg L^{-1}, as defined by Decree No. 18/2004 of 2 June (Mozambique, 2004). However, no such testing was carried out in the evaluated workshops, reflecting weaknesses in local environmental oversight and management.

During field visits, oil stains were observed on the pavement around the WOSBs, suggesting irregular emptying practices. Only one workshop (2.9%) presented adequate sealing and maintenance. The condition of the covers was used as an indirect indicator of maintenance, revealing that structural neglect is common and reflects the absence of standardized procedures.

Additionally, inadequate disposal of both liquid and solid residues generated in the WOSBs was identified. Settled sludge was discarded as regular waste, while liquid effluents were discharged into the sewage system or directly onto public roads. WOSB sludge is classified as industrial waste and must be collected by specialized companies and sent to industrial landfills (Moisa; Kaskantzis, 2005).

The results indicate that WOSB use in the workshops remains limited and poorly managed, and that installation, maintenance, and operational practices fall short of both legal requirements and recommended environmental standards. This reinforces the need for oversight and corrective measures to promote the principles of prevention and environmental sustainability established in national legislation (Mozambique, 2014; Ucker *et al.*, 2023).

4.2.3 Lubricating oil change (LOC) analysis criterion

Practices related to lubricating oil change (LOC) in the workshops are still largely empirical and carried out without environmental controls, especially regarding the storage and final disposal of used lubricating oil (ULO). As shown in Table 1, most workshops (68.6%) store ULO in metal or plastic drums, while 31.4% rely on plastic jerry cans or buckets, often in inadequate condition. When these containers are used without technical standards, the likelihood of leaks and contamination increases. A similar pattern has been reported in Brazil, where ULO is also predominantly stored in metal or plastic drums (Cipriano, 2017).

The lack of standardized handling procedures leads to improper draining and frequent spills in 74.3% of the workshops, which is not compliant with Decree No. 83/2014 of 31 December. This regulation requires hazardous waste to be stored in appropriate containers that offer compatible capacity and safety measures capable of preventing environmental contamination (Mozambique, 2014). Manual handling and the use of improvised tools during oil changes further heighten the risk of occupational accidents (Costa; Santos, 2015).

All workshops assessed showed inadequate disposal of ULO. The residue is often sold for alternative uses, such as coating wooden stakes or lubricating timber, or simply discarded in vacant lots, sewage systems, or municipal waste bins. This practice poses a significant environmental threat, as residual oil can infiltrate soil, reach groundwater, and contaminate aquifers, while also harming aquatic organisms (APROMAC, 2011; Fogaça, 2015). When discharged into drainage systems, ULO forms a surface film that reduces oxygen transfer and negatively affects aquatic life (Corrêa *et al.*, 2018).

In Brazil, the recommended destination for ULO is delivery to companies authorized by the National Agency of Petroleum, Natural Gas and Biofuels (ANP) for rerefining (Cipriano, 2017). Although Mozambique does not yet have an equivalent infrastructure, national legislation assigns producers, importers, and waste management entities the responsibility for ensuring the treatment and environmentally sound disposal of hazardous waste (Canchumani, 2013; Mendes, 2020). Decree No. 83/2014 of 31 December also states that hazardous waste should preferably be sent to licensed industrial landfills (Mozambique, 2014), an infrastructure that is currently unavailable in the city of Quelimane.

According to the interviewees, ULO is often transported in unauthorized vehicles and dumped in peripheral areas, such as the municipal landfill. This practice violates Mozambican regulations, which allow transportation only by companies certified by the competent environmental authority (Mozambique, 2014). Such informal disposal reflects the lack of enforcement, the absence of adequate infrastructure, and the unavailability of hazardous-waste collection programs.

The environmental impacts associated with the improper handling of ULO are well-documented. The literature indicates that used oil can take up to 300 years to fully degrade, representing a long-term threat to soil and water resources (APROMAC, 2011). In addition, the growing number of vehicles tends to increase the volume of this waste, highlighting the need for public policies focused on recycling, refining, and environmental education. In this context, safe storage and appropriate final disposal are essential to minimize risks and align local practices with the principles of sustainable waste management (Muniz; Braga, 2015).

4.2.4 Flooring (F) analysis criterion

The condition of workshop floors is a crucial factor for preventing environmental contamination, as it directly affects the runoff and infiltration of oils and fuels. As shown in Table 1, the oil change, storage, and washing areas generally lack flooring with appropriate impermeability, which facilitates the direct contact of used lubricating oil (ULO) with the soil. Floors in areas where petroleum-derived products are handled should be impermeable to prevent spills and ensure greater environmental protection (SÃO BERNARDO DO CAMPO, [20–]; Lima; Viana, 2016).

The frequent presence of cracks and stains on the floors of the assessed workshops indicates potential contamination by fuels and oils, resulting from poor maintenance and the absence of suitable coatings. Insufficient impermeabilization compromises environmental integrity and increases the risk of pollutant infiltration into groundwater. Fully sealed, smooth-textured floors are more effective because they facilitate cleaning and reduce the absorption of oily substances (Lima; Viana, 2016; Shinde; Kumthekar, 2022).

Only one workshop (2.9%) had an impermeable floor in good condition, highlighting the weakness of environmental management practices in the sector. In addition, the lack of local regulations defining minimum technical standards for workshop flooring contributes to the persistence of this situation. The absence of appropriate infrastructure reflects the lack of enforcement and limited incentives for adopting sustainable construction technologies, undermining the principles of soil and groundwater pollution prevention and mitigation.

4.2.5 Drainage channels for spill containment (DCSC) analysis criterion

Drainage channels for spill containment (DCSC) are essential structures for directing and retaining excess oil and fuel, preventing contaminated effluents from reaching the soil and water bodies. They function as key devices for controlling and guiding surface runoff (Agostinho; Poleto, 2012). In the workshops assessed, the installation and maintenance of DCSC were limited and often restricted to the oil change area (Table 1). In several cases, the channels were not connected to the water–oil separator box (WOSB), diverting residues directly onto public roads, revealing hydraulic planning failures and a lack of enforcement.

Research on waste management in automotive workshops shows that the absence of integrated containment systems, such as channels combined with separator boxes, increases the risk of improper effluent runoff and intensifies soil and groundwater contamination (Silva *et al*., 2025). In addition, drainage channels are responsible for collecting and conveying oil and fuel residues to separator units, ensuring proper treatment and reducing environmental pollution (Moisa; Kaskantzis, 2005).

The lack of functional channels also poses risks to human health. Continuous exposure to pollutants such as petroleum-derived substances can lead to physiological and psychosocial disorders, as well as respiratory and chronic diseases in urban areas affected by contamination (Cerchiari, 2000; Nascimento *et al*., 2020; Frazão *et al*., 2023; Oliveira *et al.*, 2025). This reality reinforces the importance of well-designed and well-maintained preventive infrastructure that ensures both environmental control and public health protection.

4.2.6 Solid waste (SW) analysis criterion

According to the data presented in Table 1, the management of solid waste (SW) in the workshops shows a lack of systematic practices for segregation, storage, and disposal. The main residues observed were oil filters, empty packaging, and containers used for collecting ULO. In most cases, these materials were mixed with other types of waste and discarded with ordinary garbage, without any prior treatment. In some locations, informal collection of containers and filters by third parties was observed, with no sanitary control, increasing environmental and health risks.

Negligent handling of contaminated waste, such as filters, cloths, and rags impregnated with oil, further demonstrates the precariousness of operational conditions. Because these materials contain hydrocarbons and heavy metals, they require disposal like industrial waste. Previous studies have reported similar scenarios, noting that plastic packaging and contaminated filters are often discarded improperly or reused for domestic purposes without considering their toxic potential (Costa; Santos, 2015; Muniz; Braga, 2015).

The absence of adequate disposal is one of the main barriers to environmental compliance in workshops, as the waste generated is not sent to licensed landfills or treatment facilities, even when such options would be feasible (Moisa; Kaskantzis, 2005). This situation reflects both the lack of specialized collection infrastructure and the limited technical training of those responsible.

Mozambican legislation, through Decree No. 83/2014 of 31 December, requires entities responsible for the treatment, elimination, or energy recovery of hazardous waste to demonstrate the environmental feasibility of their operations through risk assessments and specific management plans (Mozambique, 2014). However, during this study, none of the workshops had a formal waste management plan, highlighting the gap between regulatory requirements and daily practice.

4.3 DIRECT INFLUENCE OF ULO ON THE IMMEDIATE SERVICE AREA

Considering that 97.1% of the workshops lack an impermeable floor, it becomes evident that used lubricating oil (ULO) has a direct influence on the immediate environment where oil change services take place, resulting in infiltration and soil contamination. This area of direct influence corresponds to the zone affected by first-order impacts, covering the operational and maintenance phases of activities (Menin *et al*., 2017).

From both economic and environmental perspectives, the collection and rerefining of ULO are essential strategies to prevent soil and water degradation, since the indiscriminate disposal of petroleum-based residues releases toxic substances and heavy metals that contaminate the environment and compromise groundwater resources (APROMAC, 2011; FUNASA, 2004; Marques; Marques; Toledo, 2023; Caxias, 2024; George *et al.*, 2024). These pollutants may reach aquatic ecosystems, affecting biota and causing persistent ecological impacts that are difficult to remediate.

4.4 ANALYSIS OF THE ASSOCIATION BETWEEN WORKSHOP CLASSES AND OPERATING TIME

The analysis of the association between workshop classes and operating time was based on the premise that establishments with longer operating periods tend to show higher levels of improvement and service diversification. As shown in Table 1, Class A workshops correspond to the oldest establishments, followed by Class B workshops with intermediate operating time, and Class C workshops with the shortest period of operation.

The results of the Chi-square test presented in Table 2 ($\chi^2 = 35.684$; $p = 0.000$) confirm this trend, indicating an association between the variables. However, due to the low expected frequency in several cells (77.8% with values below 5), the likelihood ratio test—which is more appropriate for this dataset—was also applied, and it likewise demonstrated results consistent with the observed association. Thus, the findings suggest that operating time is related to the ability to expand services and strengthen workshop infrastructure. Nevertheless, older facilities are also susceptible to equipment and structural deterioration, which may favour operational failures and accidental spillages (Moisa; Kaskantzis, 2005).

It was observed that one of the oldest workshops was in the final stages of rehabilitation, which may have influenced the results by yielding positive and expected values for the evaluated criteria. Therefore, the operating time of workshops shows potential to foster continuous improvement in service quality, keeping pace with the evolving maintenance and supply demands of the local context.

Table 2 – Results of the chi-square and likelihood ratio tests for the association between variables

Test / Statistic	Value	Degrees of Freedom	p-value
Pearson's Chi-Square	35,684[a]	4	0,000
Likelihood Ratio	15,925	4	0,003
Linear-by-Linear Association	16,003	1	0,000
Number of valid cases	35	-	-

[a]Based on 77.8% of cells with expected counts less than 5.
Source: Prepared by the authors.

Overall, the findings reveal that workshops in Quelimane exhibit low environmental compliance, characterised by the absence of authorised collection companies, structural deficiencies, and weak institutional oversight. Inadequate ULO management, insufficient floor impermeabilisation, lack of containment channels, and improper disposal of solid waste reflect a scenario of limited infrastructure and insufficient technical capacity among workshop operators. These shortcomings hinder regulatory compliance, increase ecological and public health risks, and indicate that environmental management in the workshops remains incipient. Addressing this situation requires integrated actions involving rehabilitation, capacity building, and continuous monitoring to ensure safer and more sustainable practices.

5 CONCLUSION

The used lubricating oil (ULO) generated in workshops in Quelimane is inadequately managed, contributing to environmental degradation and posing risks to public health. Weak enforcement and limited awareness of hazardous waste regulations further exacerbate these impacts. Nevertheless, the reuse of ULO is a viable alternative when conducted in line with sustainability principles and environmental responsibility. The results reflect a scenario common in developing countries and may support policies and actions aimed at improving environmental management.

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REFERENCES

AGOSTINHO, M. S. P.; POLETO, C. Sistemas sustentáveis de drenagem urbana: dispositivos. **Holos Environment**, v. 12, n. 2, p. 121-131, 2012.

ALBUQUERQUE, B. P. **As relações entre o homem e a natureza e a crise socioambiental**. 2007. 96 f. Trabalho de Conclusão de Curso (Graduação em Saúde Ambiental) – Escola Politécnica de Saúde Joaquim Venâncio, Fundação Oswaldo Cruz, Rio de Janeiro, 2007.

AMARANTE, I. C. S.; ALVA, J. C. R. Os impactos na saúde humana e no meio ambiente decorrentes do manejo e descarte indevidos dos resíduos de óleos lubrificantes. *In*: **SEMANA DE MOBILIZAÇÃO CIENTÍFICA**, nº21, 2018, Salvador. Anais. Salvador: Universidade Católica do Salvador, 2018. p. 11.

APROMAC – ASSOCIAÇÃO DE PROTEÇÃO AO MEIO AMBIENTE DE CIANORTE. **Gerenciamento de óleos lubrificantes usados ou contaminados: guia básico**. Cianorte: SENAI, 2011. 33 p.

BEAUD, M.; BEAUD, C.; BOUGUERRA, M. L. **Estado do ambiente no mundo**. São Paulo: Instituto Piaget, 1995. 650 p.

BRASIL. MINISTÉRIO DA SAÚDE. SECRETARIA DE CIÊNCIA, TECNOLOGIA E INSUMOS ESTRATÉGICOS. **Diretrizes gerais para o trabalho em contenção com agentes biológicos**. 3. ed. Brasília, DF: Ministério da Saúde, 2010. 64 p. (Série A. Normas e Manuais Técnicos).

CAMPOS, R. F. F.; BIUDARO, R. E. Análise da tolerância e fitorremediação de mudas de Pinus taeda sob diferentes concentrações de resíduo de lodo de curtume. **Revista Brasileira de Meio Ambiente**, v. 13, n. 3, p. 78-93, 2025.

CANCHUMANI, G. A. L. **Óleos lubrificantes usados: um estudo de caso de avaliação de ciclo de vida do sistema de rerrefino no Brasil**. 2013. 143 f. Tese (Doutorado em Planejamento Energético) – Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2013.

CAXIAS, G. O. **A gestão de riscos ambientais como impulsionador da economia circular no setor de óleos lubrificantes: estudo de caso sobre uma locadora de máquinas pesadas**. 2024. 111 f. Trabalho de Conclusão de Curso (Graduação em Engenharia Química) – Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2024.

CERCHIARI, E A N. Psicossomática um estudo histórico e epistemológico. **Psicologia: ciência e profissão**, v. 20, n. 4, p. 64-79, 2000.

CIPRIANO, P. G. S. **Estudo sobre a destinação dos óleos lubrificantes automotivos no município de Cacoal/RO**. 2017. 91 f. Trabalho de Conclusão de Curso (Bacharelado em Engenharia de Produção) — Universidade Federal de Rondônia, Cacoal, 2017.

CORRÊA, L. P.; GUIMARÃES, V. N.; HESPANHOL, L. I.; SILVA, J. V. Impacto ambiental causado pelo descarte de óleo: estudo do destino que é dado para o óleo de cozinha usado pelos moradores de um condomínio residencial em Campos dos Goytacazes – RJ. **Revista Brasileira de Planejamento e Desenvolvimento**, v. 7, n. 3, p. 341-352, 2018.

COSTA, E. S.; SANTOS, G. O. Diagnóstico ambiental dos óleos lubrificantes automotivos usados e/ou contaminados na área da secretaria regional I da cidade de Fortaleza – CE. *In*: **CONGRESSO TÉCNICO CIENTÍFICO DA ENGENHARIA E DA AGRONOMIA – CONTECC'2015**, 2015, Fortaleza. Anais. Fortaleza, 2015. p. 6.

CRIZEL, M. G.; LARA, A. C. Avaliação da eficiência de uma estação de tratamento de efluentes instalada em uma universidade federal: questão de gestão ambiental**. Revista Brasileira de Meio Ambiente**, v. 8, n. 3, p. 54-70, 2020.

DALÇÓQUIO, J. P. **Nível de satisfação dos clientes da Dalçóquio Comércio e Representações Ltda**. 2007. 109 f. Trabalho de Conclusão de Curso (Graduação em Administração - Marketing) — Universidade do Vale do Itajaí, Balneário Camboriú, 2007.

EL-FADEL, M.; KHOURY, R. Strategies for vehicle waste-oil management: a case study. **Resources, Conservation and Recycling**, v. 33, n. 2, p. 75-91, 2001.

ESPÍNDOLA, I. B.; RIBEIRO, W. C. Cidades e mudanças climáticas: desafios para os planos diretores municipais brasileiros. **Cadernos Metrópole**, v. 22, n. 48, p. 365-395, 2020.

FERREIRA, L. S. A racionalização da indústria da reparação automotiva e a resistência dos mecânicos aos modelos de competência e de empreendedorismo. **Revista de Ciências Sociais**, v. 59, n. 2, p. 517-551, 2016.

FOGAÇA, P. H. C. **Contaminação do lençol freático por hidrocarbonetos na região de Avaré – SP**. 2015. 160 f. Dissertação (Mestrado em Engenharia) — Universidade Estadual Paulista "Júlio de Mesquita Filho", Faculdade de Engenharia, Bauru, 2015.

FORTES, A. G.; ALFÂNDEGA, M. Gestão de óleo lubrificante usado e suas embalagens na cidade de Nampula – Moçambique. **Tecnia**, v. 7, n. 1, p. 19, 2022.

FRAZÃO, L. F. N.; CARDOSO, L. E. L. C.; BARBOSA, D. C.; LISBOA, H. K. X.; SANTOS, L. P.; SILVA, K. K. L.; PEREIRA JÚNIOR, V. M.; FONSECA, M. A. R.; GOMES, C. A.; ALVES, L. S.; PEDON, I. C. Z.; SANTOS, A. M. Efeitos patológicos da exposição de poluentes atmosféricos à saúde humana: uma revisão integrativa. **Contribuciones a Las Ciencias Sociales**, v.16, n.10, p. 23325-2334, 2023

FUNASA – FUNDAÇÃO NACIONAL DE SAÚDE. Manual de saneamento. 3. ed. Brasília, DF: Funasa, 2004. 165 p.

GEORGE, I. I.; NAWAWI, M. G. M.; MOHD, Z. J.; FARAH, B. S. Environmental effects from petroleum product transportation spillage in Nigeria: a critical review. **Environmental Science and Pollution Research**, v. 31, p. 1719-1747, 2024.

GONZAGA, N. C.; SILVA, R. N.; ANDRADE, L. P. Gerenciamento de resíduos do óleo lubrificante: uma revisão sistemática da literatura. **Revista de Gestão Social e Ambiental**, v. 15, p. 1-16, 2021.

INE – INSTITUTO NACIONAL DE ESTATÍSTICA. **Estatísticas do Distrito de Quelimane**, 2019–2023. Maputo: INE, 2024. 37 p.

Lima, M. B. O; Viana, E. Geração e gerenciamento dos resíduos sólidos em uma oficina Mecânica. **Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental**, v. 20, n. 1, p. 533−551, 2016.

LORENZETT, D. B.; ROSSATO, M. V. A gestão de resíduos em postos de abastecimento de combustível. **Revista Gestão Industrial**, v. 6, n. 2, p. 110-125, 2010.

MAEFP – MINISTÉRIO DA ADMINISTRAÇÃO ESTATAL E FUNÇÃO PÚBLICA. **Diagnóstico integrado de infraestruturas e serviços básicos para os municípios da Província da Zambézia: relatório de diagnóstico – Município de Quelimane**. Maputo: Ministério das Obras Públicas, Habitação e Recursos Hídricos; Ministério da Terra e Ambiente; COWI Moçambique, 2020. 268 p.

MANUEL, A. A. A**. Análise da situação actual da gestão de óleos lubrificantes usados**. 2013. 41 f. Trabalho de Conclusão de Curso (Graduação em Engenharia Ambiental) – Universidade Eduardo Mondlane, Maputo, 2013.

MANUEL, B. Gestão de resíduos sólidos nos centros urbanos de Moçambique: estudo de caso da cidade de Nampula. **Revista Científica Interdisciplinar**, v. 2, n. 2, p. 15, 2025.

MARQUES, D. D. S.; MARQUES, M. S.; TOLEDO, A. L. Dos gases de emissão de um motor de combustão interna ciclo diesel: uma análise a partir da utilização de biodiesel residual de Brassica napus – B13, B20, B30 e B40 – comparado ao diesel S10. **Revista Brasileira de Meio Ambiente**, v. 11, n. 2, p. 129-139, 2023.

MAZALLI, A. V. G. **O destino final do óleo lubrificante automotivo usado no município de Assis**. 2010. 66 f. Trabalho de Conclusão de Curso (Graduação em Química) – Fundação Educacional do Município de Assis, Assis, 2010.

MENDES, J. P. N. B. **Gerenciamento de óleos lubrificantes usados em estabelecimentos comerciais de Lavras, MG**. 2020. 68 f. Trabalho de Conclusão de Curso (Bacharelado em Engenharia Ambiental e Sanitária) – Universidade Federal de Lavras, Lavras, 2020.

MENDONÇA, F. **Geografia e meio ambiente**. 9. ed. São Paulo: Contexto, 2012. 82 p.

MENIN, F. A.; REIS, F. A. G. V.; GIORDANO, L. C.; AMARAL, A. M. C.; GABELINI, B. M.; CERRI, R. I. Critérios de delimitação de áreas de influência em estudos de impacto ambiental de rodovias: abordagem de processos de dinâmica superficial. **Revista do Instituto de Geociências** – USP, v. 17, n. 3, p. 209-224, 2017.

MOÇAMBIQUE. Decreto nº 13/2006, de 15 de junho: **Regulamento sobre a gestão de resíduos**. Boletim da República, n. 24, 1ª série, p. 37, 2006.

MOÇAMBIQUE. Decreto nº 18/2004, de 2 de junho: **Regulamento sobre padrões de qualidade ambiental e de emissão de efluentes**. Boletim da República, n. 22, 1ª série, p. 24, 2004.

MOÇAMBIQUE. Decreto nº 25/2011, de 15 de junho: **Regulamento relativo ao processo de auditoria ambiental**. Boletim da República, n. 24, 1ª série, p. 18, 2011.

MOÇAMBIQUE. Decreto nº 54/2015, de 31 de dezembro: **Regulamento da avaliação do impacto ambiental**. Boletim da República, n. 104, 1ª série, p. 21, 2015.

MOÇAMBIQUE. Decreto nº 56/2010a, de 22 de novembro: **Regulamento ambiental de operações petrolíferas**. Boletim da República, n. 46, 1ª série, p. 8, 2010.

MOÇAMBIQUE. Decreto nº 67/2010b, de 31 de dezembro: **Regulamento sobre padrões de qualidade ambiental e de emissão de efluentes**. Boletim da República, n. 52, 1ª série, p. 5, 2010.

MOÇAMBIQUE. Decreto nº 83/2014, de 31 de dezembro: **Regulamento sobre gestão de resíduos perigosos**. Boletim da República, n. 105, 1ª série, p. 34, 2014.

MOÇAMBIQUE. Lei nº 13/2023, de 25 de agosto: **Lei do Trabalho**. Boletim da República, n. 165, 1ª série, p. 45, 2023.

MOÇAMBIQUE. Lei nº 20/97, de 1 de outubro: **Lei do Ambiente**. Boletim da República, n. 40, 1ª série, p. 6, 1997.

MOISA, R. E.; KASKANTZIS NETO, G. Avaliação de passivos ambientais em postos de serviço através do método de análise hierárquica de processo. *In*: **CONGRESSO BRASILEIRO DE P&D EM PETRÓLEO E GÁS**, 3., 2005, Salvador. Anais. Salvador, 2005. p. 6.

MUNIZ, I. C.; BRAGA, R. M. Q. L. O gerenciamento de óleos lubrificantes usados ou contaminados e suas embalagens: estudo de caso de uma empresa de logística na região Norte do Brasil. **Revista Eletrônica Sistemas & Gestão**, v. 10, n. 3, p. 442-457, 2015.

NASCIMENTO, G. R. E., DANCONI, J., LIPORACI, B. D. P. C.; REZENDE, R. M. Meio ambiente sustentável como fator determinante para a saúde. **Atas de Saúde Ambiental**, v. 8, p. 62-62, 2020.

Oliveira, A. R. P.; Andrade, I. M. F. L; Araújo, A. A; Nogueira, V. F. B; Dantas, J. S; Lima, P. C. C; Leite, F. S. L. S.; Casimiro, M. R. A.; Leite, M. D. S. Poluição ambiental e doenças psicossomáticas: desafios e estratégias de mitigação na saúde pública. **Contribuciones a Las Ciencias Sociales**, v.18, n.3, p. 01-15, 2025.

PEEL, M. C.; FINLAYSON, B. L.; MCMAHON, T. A. Updated world map of the Köppen-Geiger climate classification. **Hydrology and Earth System Sciences**, v. 11, p. 1633-1644, 2007.

QUINHÕES PINTO, R. A.; TORTATO, U.; VEIGA, C. P.; CATAPAN, A. Gestão de estoque e lean manufacturing: estudo de caso em uma empresa metalúrgica. R**evista Administração em Diálogo** – RAD, v. 15, n. 1, p. 111-138, 2014.

ROCHA, B. S.; SCALIZE, P. S.; ARRUDA, P. N.; CRUVINEL, K. A. S. Gestão do óleo lubrificante usado em postos de combustíveis no município de Terezópolis de Goiás – GO, Brasil. **Revista Monografias Ambientais** – REMOA/UFSM, v. 13, n. 4, p. 3673-3682, 2014.

SÃO BERNARDO DO CAMPO. Secretaria de Gestão Ambiental. **Guia orientador: gestão ambiental nas oficinas reparadoras de veículos**. São Bernardo do Campo: Secretaria de Gestão Ambiental, [20–]. 18 p.

SECRON, M. B.; GIORDANO, G.; BARBOSA FILHO, O. Avaliação de sistemas separadores água e óleo do tratamento de efluentes de lavagem, abastecimento e manutenção de veículos automotores. *In*: **CONGRESSO INTERAMERICANO DE ENGENHARIA SANITÁRIA E AMBIENTAL – AIDIS**, 30., 2006, Punta del Este. Anais... Punta del Este: Asociación Interamericana de Ingeniería Sanitaria y Ambiental – AIDIS, 2006. p. 11.

Shinde, M.; Kumthekar, M. Advanced flooring materials and their limitations with special reference to casting and pharmaceutical industries. **International Journal of Creative Research Thoughts**, v.10, n. 9, p. a330-a336, 2022.

SILVA, T. A.; OLIVEIRA, K. M. Descarte de óleos lubrificantes e suas embalagens: estudo de caso dos postos de gasolina e oficinas da cidade de Ituiutaba, estado de Minas Gerais. **Revista Eletrônica de Geografia**, v. 3, n. 7, p. 101-114, 2011.

SILVA, T. B. S.; SHEILA, F. S.; FREITAS, G. H. L.; GALHARDO, C. X.; AMORIM, M. C. C. Biodegradabilidade de águas cinzas e efeito de meio filtrante composto por vidro triturado na eficiência do tratamento. **Revista Brasileira de Meio Ambiente**, v. 13, n. 3, p. 94-109, 2025.

UCKER, F. E.; KEMERICH, P. D. C.; MATIAS, R. K.; PEIXOTO, L. B. B. Análise dos separadores de água e óleo em postos de combustíveis**. Revista Foco**, v. 16, n. 11, p. 1-13, 2023.

WILLING, A. Lubricants based on renewable resources – an environmentally compatible alternative to mineral oil products. **Chemosphere**, v. 43, p. 89-98, 2001.