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Effectiveness of Waste Management Practices for End-of-Life Vehicle Components in the City of Nairobi, Kenya

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Abstract

Similar, to many other developing countries, Kenya is a major market of second-hand (used) cars from Europe and Japan, which is likely to cause serious environmental effects since the rise of the older motor vehicle population in the country results in the volume of End-of-Life Vehicles' (ELV) waste. There is therefore need to assess the ELV waste streams in the country. This study aimed at assessing the ELVs Environmental Management Systems in Nairobi City County, Kenya. The study used mixed research methods. A sample size of 62 firms comprising of 32 garages, 15 insurance firms, and 15 salvage companies was selected from Nairobi City County, using a stratified and convenient sampling techniques.. A semi-structured questionnaire was used to collect the required information from firm owners and/or managers, and descriptive statistical techniques comprising of frequency tables, percentages, pie charts, and bar graphs were used to summarize, present, and analyse the information in an informative way. Research findings indicated that the ELV waste products were associated with four main waste streams mainly, the insurance firms, garages and salvage companies and vehicle junk yards. The practices employed to manage ELV waste included contracting salvage firms to collect written off vehicles by insurance companies, recycling of salvaged parts, selling the usable parts to dealers of vehicle parts, and disposal of non-salvageable parts including hazardous products via firm mechanisms such as collecting the material and putting fluids in tanks and disposing them off in designated dumpsites. The findings of the research were that management of ELV waste in Nairobi City County was inadequate, with most waste streams, especially garages and salvage firms lacking formal ELV management plans, and disposal of hazardous material pauses a great danger to environmental health. It is recommended that stringent waste management policies and guidelines for the salvage companies and garages should be put in place to mitigate against environmental pollution.

Keywords: End of life vehicle; Insurance companies; Salvage companies; Recyclable waste; Non-recyclable waste; Hazardous waste; Recycling; Disposal

Introduction

Due to the proliferation of a middle class and an increase in income levels, Africa despite having an underdeveloped automotive industry has a significantly high adoption rate of the technology [1]. A common trend in the automotive retail sector across the African region is the dominance of second-hand vehicles, which are mainly imported. Schiller & Pilay [1], for example, indicate that 8 out of 10 imported cars in Nigeria, Ethiopia and Kenya are used vehicles.

Globally, the number of End-of-Life Vehicles (ELVs) emanating from 24 European Union (EU) member States have been on the increase since the 2005. For instance, in the years 2005, 2008 and 2010, there was 6.2 million, 12.7 million and 14 million ELV volumes, respectively (European Vehicle Market Statistics, 2013). Many vehicles that have been de-registered in the member states are exported as second-hand autos. The question of when a used car ceases to be a product and becomes rubbish is highly subjective and is resolved differently across the EU member states.

It is projected that Kenya will have over 500 million cars on the road by 2030 [1]. With the growing number of automobiles on the road worldwide and Kenya in particular, among the issues of concern include the pertinent questions of what will happen to the vehicle shells when they reach the end of their useful lives, and what environmental challenges will accompany the increase [2]. According to Muiruri [3], road transport accounts for 93 percent of passenger and freight movement in Kenya, with over 1.3 million registered cars, of which almost 780,000 (roughly 60%) are in use.

Previous research has shown that vehicles reach the end of their lives when they become too old and worn out to be roadworthy ("natural" end of life vehicles or NELVs) or when they are written off as a result of an accident ("premature" end of life vehicles or PELVs) [4]. Vehicles can be sold for export either before or after they have reached the end of their useful lives as used vehicles. Transactions involving used cars and ELV (waste) are treated differently because only the latter is subject to waste legislation.

The proliferation of end-of-life vehicle waste products on the African continent has also been viewed from the perspective of a culture of dumping waste material within African countries' environments that some industrialized countries had adopted, before legislative efforts deterred the activities related to dumping of hazardous wastes such as barrels of containerized raw sewage, sludge, incinerated ashes, contaminated soils, chemical substances, acids, and poisonous solvents [5]. According to information from the Africa Waste Trade Cases [6], some African nations were enticed to accept hazardous materials by the prospect of earning a sizable sum of money that could account for a significant increase of their gross domestic product (GDP). A toxic waste trade deal was too alluring to resist when $20 million was promised, which would represent a substantial increase in national income for a country like Guinea-Bissau that was in dire need of aid. End-of-life automobiles, refrigerators, air conditioners, and other comparable items have become increasingly popular as hazardous waste dumps.

The Port of Antwerp is believed to be the most important Belgian port and a key gateway for trade with West Africa, handling used vehicles in containers bound for Africa from the United States [7]. In the East Africa region, including Kenya, Dubai and Japan are main sources of used vehicles. This unregulated trend of importation of used cars from developed nations to developing nations, especially Africa is wanting in the sense that it contributes to the increase in ELV waste products.

Increasing pressures and challenges to enhance economic and environmental performance have prompted developing countries in general, and vehicle manufacturers in particular, to think about and implement ELV management. It is becoming a major issue that will not only prevent environmental degradation but also assist manufacturers economically [8]. There are various recovery methods available when a product approaches its End-of-Life (EoL), including reusing the product or its components, remanufacturing, material recycling, incineration, and landfilling [9]. Figure 1 is a summary of description of ELVs generation and management.

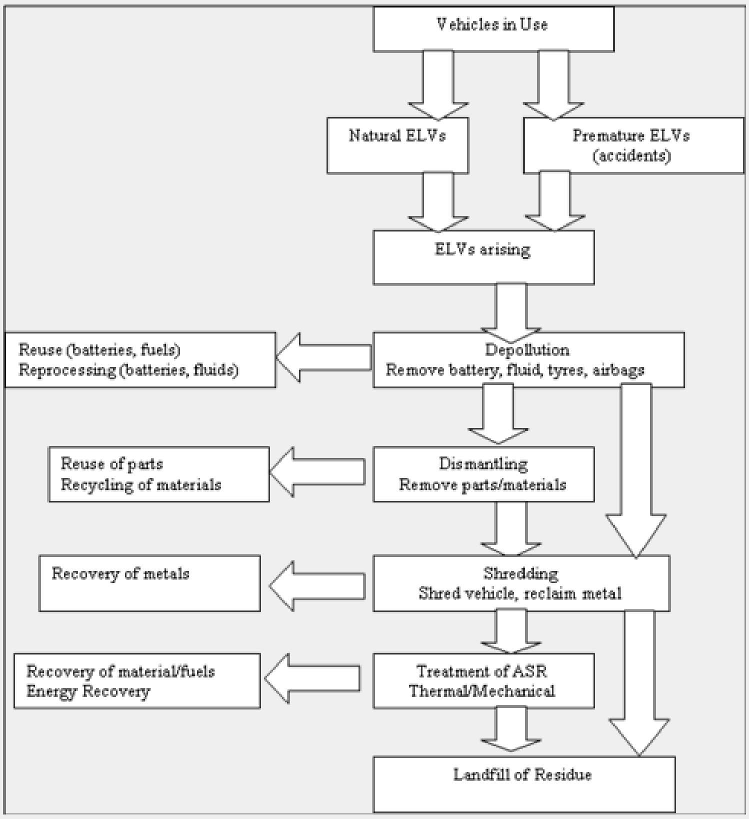

Figure 1: Description of ELV generation and treatment (Mansour & Zarei, 2008).

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End-of-life vehicles have the potential to contaminate the environment, through contamination of land and water supplies by leaking fluids such as engine oil, possible injuries due to rusting broken vehicle parts, and as breeding places for rodents, mosquitoes, and other pathogens [3]. The automobiles also create visual pollution due to accumulation in dumping and storage sites. According to Muiruri [3], in Kenya, if the problem of unclaimed automobiles demands is not addressed promptly, it will deteriorate as motorization and population grow rapidly. However, he further illustrated that ELVs can cause contamination to the environment and thus the need for ELV recycling.

When looking at studies on vehicle recovery infrastructure from an empirical perspective, Kumar & Sutherland [10] discovered the following shortcomings in the mathematical models that were already in use: insufficient description of intricate material flows and economic transactions within the infrastructure, scant consideration of market factors, and disregard for governmental policies. Ilgin & Gupta [11] conducted a review of the literature on environmentally responsible manufacturing and product recovery and came to the conclusion that more research was necessary to better mitigate the negative effects of uncertainty in environmental conservation.

When Joung et al. [12] examined the expansion of ELV recycling in Europe, they discovered that shipping ELVs to China was less expensive than processing them there. According to Joung et al. [12], who examined the state of ELV recycling in Korea, the installation of advanced sorting equipment in a vehicle shredding plant could optimize separation efficiency and increase the reached recycling rate.

In-depth analysis of Taiwan's ELV recycling system was conducted by Chen et al. [13], who concluded that tactical and operational planning needed to be improved and optimized to increase the competitiveness of recycled materials. Production capacity, power efficiency, and recycling rate were used as metrics to examine the operational aspects of the recycling and treatment industry for ELVs in Taiwan and their relationship to recycling performance. They suggested that vehicle shredding facilities upgrade their work schedule in order to increase the recycling rate of ELVs. Wang & Chen [14] investigated China's approaches to the development of recycled electronic control components for automobiles. They weighed the advantages, disadvantages, possibilities, and potential obstacles. They came to the conclusion that the ELV recycling industry has successfully addressed every cause.

According to Altay et al. [15], if the necessary regulations are put in place, Turkey's current rate of vehicle recycling could lead to the creation of a new job sector. Seven sustainability metrics were presented by Vermeulen et al. [16] and can be used to compare and evaluate different industrial waste treatment methods. The suggested method for conducting an overall sustainability assessment is tested using the ASR case study. Recycling combined with energy recovery was the most environmentally friendly processing method, enabling the EU ELV Directive quotas to be met by 2015.

The implementation of efficient ELV waste management has been hampered by a decline in the global market value for steel scrap and a high cost of processing ELV waste, despite the fact that ELVs contain more than 70% iron, which has historically been marketed as a valuable secondary resource in nations like Kenya with their recycling done independently using market procedures [17]. This study aims to evaluate the ELV waste streams, products, and management techniques in Kenya, with a particular emphasis on Nairobi, the nation's capital city, which naturally has the most vehicles and, consequently, the most ELVs. This investigation may help find long-lasting solutions.

Methodology

Study area

The study area is Nairobi City County (Figure 2) which is one of the 47 counties in the Republic of Kenya. It is also the political and commercial center of Kenya, a destination of the largest number of imported vehicles in the country. The county is bordered on the east by Machakos County, on the north by Kiambu County, and on the south and west by Kajiado County. Kiambu County has the longest border with Nairobi City County among the three adjacent counties. The county is located between longitudes 36º 45' East and latitudes 1º 18' South and has a total size of 696.1Km^2 (269 square miles). Its elevation is 1,798 meters above sea level [18].

One of the key reasons driving Nairobi's overwhelming environmental degradation is the county's large and rising population. Increased vehicle numbers, unplanned and uncontrolled settlements, poor solid waste management, uncontrolled development, untreated industrial discharge, and inefficient energy use are all contributing factors. Industrial and motor vehicle emissions are the most significant contributors to climate change. Pollution control methods are impeded by a lack of enforcement capacity for existing environmental legislation. The County's environmental degradation has contributed to biodiversity loss, floods, and habitat destruction along river basins. As a result of pollution, health and sanitation standards have deteriorated [18].

In Nairobi and Kenya in general, solid waste management (SWM) is still a serious public health and environmental concern. Low coverage of solid waste collection, pollution from uncontrolled waste dumping, inefficient public services, an unregulated and uncoordinated private sector, and a lack of key solid waste management infrastructure characterize Nairobi's solid waste situation, which could be taken to represent Kenya's overall situation. The amount of solid garbage produced each day in Nairobi is 4,016 tonnes (Allison, 2010). The collection rate is as

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low as 33% [19,20], resulting in an uncollected amount of 2,690 tonnes. Other actors have entered the picture, including private firms and community-based organizations, in addition to the Nairobi City County Government (NCCG), which is responsible for the supply and regulation of SWM services throughout the county. Some of these actors' operating models are not well known. Effective coordination among these parties is also lacking, and the city council's control of private firms is now just starting. This research intends to learn more about what has been done on a national level to implement an ELV waste management system. The policy frameworks will also be evaluated in order to identify policy gaps and provide appropriate recommendations based on findings from other nations.

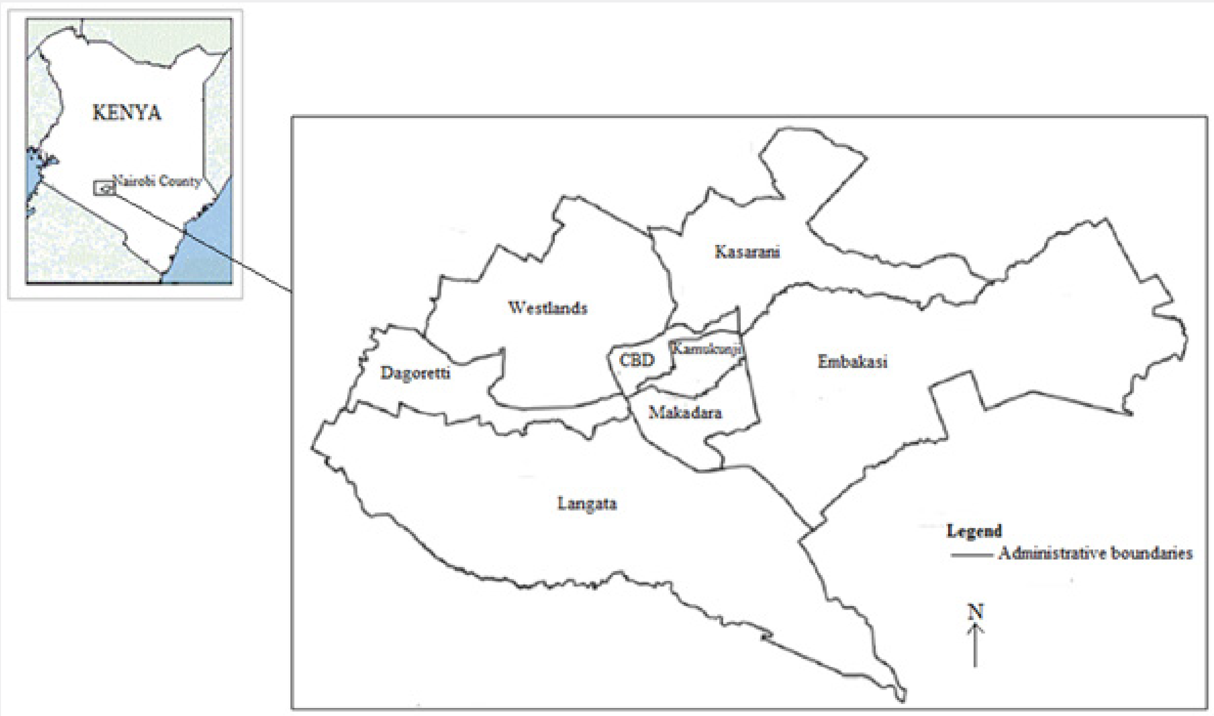

Figure 2: A map of Nairobi City County and its sub-counties. (Adopted from Omondi et al., (2019).

Research design

The study utilized mixed method research design, with its primary data being collected by a semi-structured questionnaire comprising of open and close-ended questions from a stratified sample that comprised 32 garages, 15 salvage firms, and 15 insurance firms located within Nairobi City County, resulting in total sample size of 62 firms. Targeting the firm owners and/or managers, as well as underwriters in insurance firms, the respondents in each stratum were selected using a convenient sampling technique, and a response rate of 81% (26 respondents), 73% (11 respondents) and 93% (14 respondents) was achieved for car garages, salvage firms, and insurance firms, respectively. The investigation of Nairobi's ELV waste management practices, including the current recycling, reusing, reducing, and disposal practices of ELVs, formed the other section of the study. The primary points of interest to assist in evaluating the current ELV waste management practices were identified as the motor vehicle salvage businesses, auto repair shops, junkyards, and the infamous Dandora Dumpsite run by NCCG.

The purposive and qualitative survey approaches were found to be the best options for choosing the study's sampling frame. For instance, the Kenya Revenue Authority (KRA) and the National Transport and Safety Authority (NTSA) provided information on the quantity of used vehicles imported into the nation. While the NTSA, which was founded in 2016, could only provide data between 2017 and 2019, KRA and other alternative data sources, like the National Bureau of Statistics, could easily provide data between 2012 and 2017. Because the study areas were primarily focused on the management of ELVs and ELV wastes, NEMA, NTSA, NCCG, KRA, and IRA were identified as relevant organizations to participate in the survey.

Descriptive statistical techniques comprising of numerical frequency summaries and descriptive numerical measures of percentages, as well as graphical techniques of pie charts and bar

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graphs were instrumental in organization and summarization of the data collected via the questionnaire in an informative way. Word description and/or narration of the outcomes using MS Word accompanied the numerical and diagrammatic presentation.

Results

The specific objectives of the research focused on identifying the end-of-life vehicle waste products associated with the waste streams under consideration, which include; the insurance companies, motor vehicle garages, and salvage companies and their waste management techniques. The findings associated with each waste stream are highlighted below.

ELV waste stream 1: insurance firms

The motor vehicle underwriters commonly known as the insurance firms were found to be the key source of ELVs. Various classes of vehicles are insured by these underwriters who take responsibility for client vehicles once involved in accidents. All the underwriters interviewed, representing a 100% response rate, agreed that depending on the extent of the accidents, they may opt to repair the vehicles or write them off. The vehicles are declared write-offs if the cost of restoring the vehicle may be higher than the value of the car in its state or if the level of damage may not allow for restoration of the vehicle to its original state.

Figure 3 shows the annual number of insured and written-off vehicles by the insurance firms surveyed. During the 6 years between 2014 and 2019, the 14 motor vehicle insurance firms surveyed were able to underwrite a total of 766,127 vehicles within Nairobi County. This translated to the insurance of averagely 127,787 vehicles annually within this period. It was also found that a total 191,526 units were written-off within these 6 years which translated to an average of 31,921 vehicles written off annually. The least number of annual written-off vehicles was recorded in 2014 at 24,846 units and the maximum number of vehicles in 2019 at 37,946 units. From these findings, the ratio of the number of vehicles written-off and the number of vehicles insured was 1:4 implying that approximately out of every four vehicles that are insured one will be written off within the year. All the 14 insurance firms had outsourced motor vehicle salvage companies and garages to handle the written-off vehicles: findings on this stream of ELVs shall discussed in the next subsection.

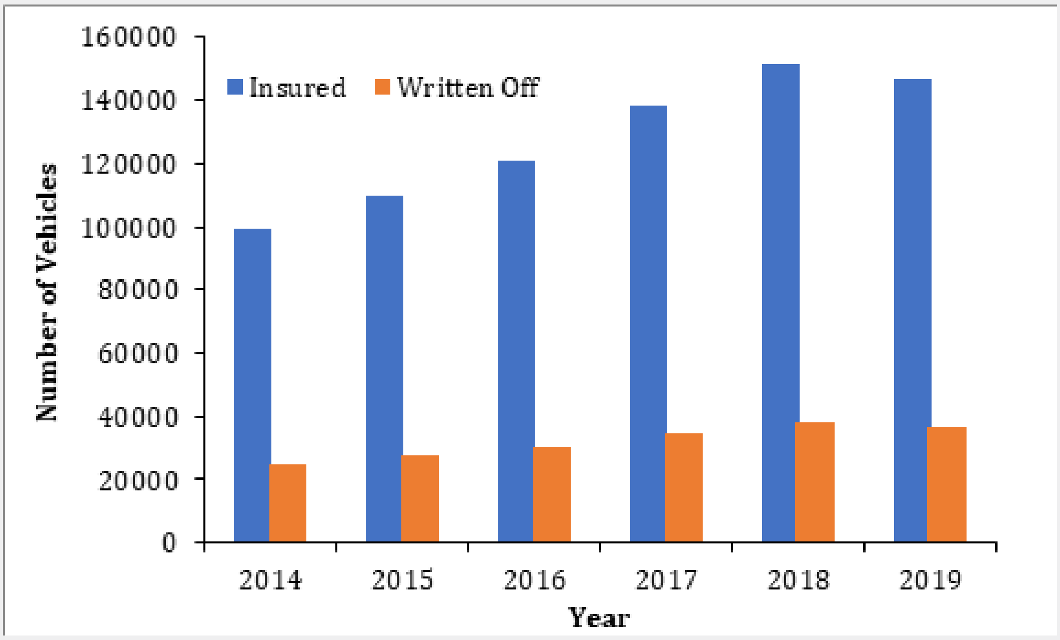

Figure 3: Number of insured and written-off vehicles in Nairobi between 2014 and 2019.

ELV waste stream 2: the motor vehicle salvage companies

Between 2014 and 2019 the salvage companies received from the insurance companies an average of 25,080 vehicles that had been written-off. All the motor vehicle salvage companies surveyed indicated that they preferred restoration of the written of vehicles as the first resort. The second resort in line was to dismantle the vehicle and sell its parts as used spares to car part shops or dealers. It was also determined that 70% of the vehicles received were restored while the remainder was recycled as second-hand vehicle parts or collected for sale as scrap whereas

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tyres were sold off to dealers who buy and sell second hand tyres. Hundred percent of the respondents disclosed that non-reusable and non-recyclable parts were disposed of for dumping.

All the 11 salvage companies surveyed did not have a predesigned dismantling and depollution procedure. Only five out of the 11 companies had installed oil and water interceptors to their drainage systems (Figure 4). These 5 companies had also contracted hazardous waste management firms to collect oil waste among other vehicle effluents such as brake fluid and the automatic transmission fluid. The other 6 companies collected their wastes in containers and disposed them with general wastes.

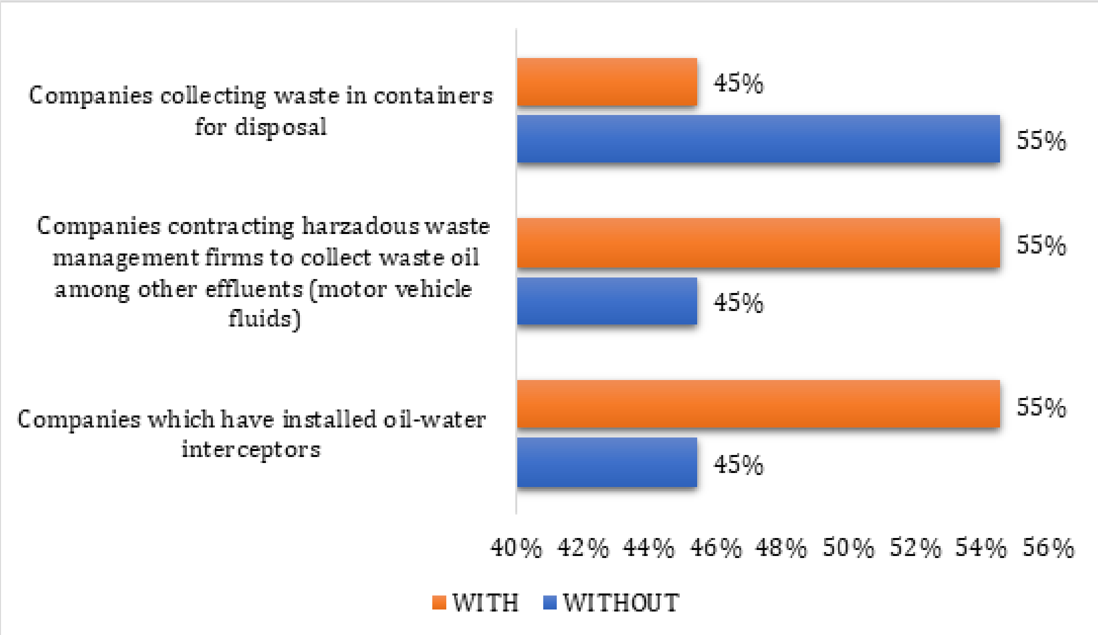

Figure 4: Management if ELV waste by motor vehicle salvage firms.

ELV waste stream 3: the motor vehicle garages

Figure 5 shows the proportions of different waste types produced at the garages. The wastes were either in the solid or liquid form and were further classified as, recyclable, non-recyclable and hazardous. Recyclable waste comprised the largest amount of waste produced at 49%, non-recyclable wastes at 13% and hazardous wastes were at 38%. Recyclables in garages were mainly; metals and plastics, car batteries and rubber (tyres), non-recyclable waste comprised of spoilt seat covers and sponges, electronic parts, whereas hazardous wastes observed included waste fuel and used engine oil, oil filters, transmission fluid, power steering fluid, brake fluid, vehicle coolant, acid from car batteries, solvents, degreasers and lubricants.

In all the 32 garages that were surveyed, it was found out that there was little effort made to separate their wastes, and that only the recyclable waste was deemed valuable and was separated from the rest of the waste. The non-recyclable and hazardous wastes were collected for disposal. In addition, it was found that only 4 (12.5%) had put in place a waste management plan whereas the remaining 87.5% did not have a waste management plan in place. The 4 garages which had a waste management plan in place separated their wastes while the others did not. None of the garages surveyed had a comprehensive dismantling procedure for ELVs.

Seventeen (17) out of the 32 garages, representing 55% of the total number of vehicles were found to be disposing liquid vehicular waste through licensed hazardous waste collectors, whereas most of the solid wastes were either burnt or collected by regular waste collectors. From the field observations, it was noted that 100% of the garages disposed of inorganic vehicle waste together with bio-degradable commercial and domestic waste. All the 32 garages assessed reported that they dispose of their solid wastes using the regular domestic waste collectors and that there was no specific waste collection firm that dealt with motor vehicle waste.

End-of-Life vehicle parts were either piled on open ground at designated areas within the garages or in containers awaiting collection by a general solid waste collection firm. Out of the

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32 garages, 10 reported that they use private waste collectors, representing 31.3% of the total sample while the larger 68.8% dumped their solid wastes at central collection points and bins provided by the Nairobi County Government. Twenty (20) garages representing 62.5% of the total sample reported that they sold ELV parts as used spares.

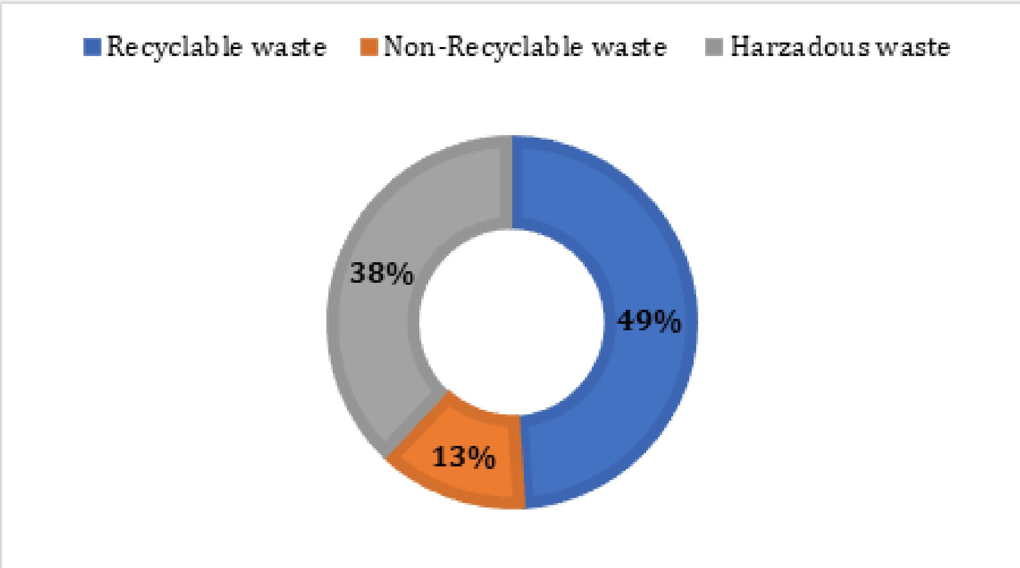

Figure 5: Distribution of recyclable, non-recyclable, and hazardous waste from the garage waste streams.

Out of the 32 garages, only 10 had concrete floors representing 31.3% of the total sample while the 22 (68.8%) had earth floors. Five (5) out of the 10 garages were situated within petrol stations and were fitted with oil-water interceptors. In some instances, vehicular wastes were left to pile up in the garage such as waste tires, broken panes among other solid malfunctioned vehicle parts and disposed later at the will of the garage's management.

Waste management facilities

Based on the Environmental Management and Coordination Act (EMCA) Waste Management Regulations [21] the only waste management facilities that were found to be designed to standard were the facilities handling hazardous waste. Responses from the various ELV waste streams generators established that the non-hazardous and non-recyclable solid wastes were collected and disposed of at the Dandora dumpsite, the main solid waste disposal site for Nairobi City County (NCC). As evident during field observations some of the waste received at the dumpsites was mixed with hazardous wastes from the salvage companies, garages and junkyards. It was also observed that failure by the County government to timely collect solid waste from the source led to accumulation of the wastes and associated illegal disposing of their wastes at uncontained collection points once their bins are full.

The study also found that there was no waste collection firm that was designated to specifically collect ELV waste. Key informants from the NCC reported that ELV wastes disposed at the dumpsite are mixed with the general wastes during collection and that there was no designated area for ELV wastes at the main dumpsite. The NCC management only weighs the general waste at the entry bridge and the waste truck dumps the waste at appropriate sections as directed by the dumpsite's management, dumpsite cartels and waste foragers. Interviews with the key informants revealed that there were no specific institutions, organizations or companies that were working with NCC on the management of ELV waste. There were also no Authorised Treatment Facilities (ATFs) which ought to issue a certificate of destruction prior to destruction of any vehicle as is the case with EU countries [22].

Discussion

Steel, aluminum, copper, and plastics are among the many materials used to construct automobiles. Steel continues to be the most heavily used component in automobiles, accounting for more than 60% of the weight of the average vehicle [23]. Steel is viewed by automakers as a cost-effective, highly formable material that maintains its durability, strength, and stiffness and also given that aluminum is more expensive than steel [24]. As provided in Kenya's Traffic Act, CAP 403, a Class B1 vehicle is a light passenger vehicle that weighs an average of 3500kgs. With reference to components of a vehicle being made of non-biodegradable material, an average of 31,921 vehicles written off annually will translate to approximately 31,921*3500=111723500Kgs or approximately 111,723 tonnes of a non-biodegradable

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composition. With reference to the aforementioned data on steel stocks and automobile steel composition, an annual average of 31,921 vehicles written off in the City of Nairobi converts to a significant volume of steel if recovered and recycled.

According to Sullivan [25], the amount of steel stocks in use in the United States in 2002 was 4.13 billion metric tonnes, with vehicles being one of the main contributors. United States Geology Survey (2005) revealed that already processed steel in automobiles indirectly forms part of the US steel stock. With respect to these findings and comparing with the Kenyan situation, ELVs can raise a reasonable amount of resources when these materials or parts can be resold for reuse, segregated and recycled.

As per the results, all 14 insurance firms had a standing contract with salvage companies to receive the written-off vehicles. These firms and the junkyards were identified as next line in the ELV waste stream. These salvage companies, junkyards and garages did not have predesigned dismantling and de-pollution procedures to facilitate for effective handling of ELV waste. The 3R Integrated Solid Waste Management (ISWM) Principles were not applied by all these ELV waste handlers. Best practices at these point sources can be applied through the regulation of these ELV and ELV waste handlers. These organizations also ought to have sufficiently equipped facilities that can aid in the implementation of the 3R principles.

The study found out that the identified waste streams and the NCCG lacked strategic management plans to facilitate for implementation of the 3R principles. The waste management hierarchy begins at the source and this, therefore, means a management structure should be the first resort to guide parties dealing in the sector on how best to manage ELVs and ELV waste. This can only be actualised through policy frameworks that will facilitate in implementation of such strategies. The European Union established the ELV Directive [22] whose main aim was to make dismantling and recycling of ELVs friendlier to the environment.

The survey findings revealed that 100% of the insurance firms did not directly handle ELV waste but engaged the services of salvage companies and garages. The salvage companies did not deal with the written-off vehicles only as waste but rather tried to restore them to their original state; vehicle parts that were affected were removed for recycling or disposal depending on the parts' material i.e., if made from metal, plastic or rubber. Plastics recycling, automobile glass management, waste tire management, mercury-containing switches, aluminium scrap sorting, and design for recyclability are six important priority areas in ELV management, according to Jeff & Gregory [26]. They also offered an overall ELV processing system and associated materials streams, which included ASR dismantling, shredding, material separation and processing post-shredder, and eventually landfill disposal. They also stated that when a vehicle was decided to be retired from the road, it was transported to one of two categories of dismantlers: High Value Part Dismantlers and Salvage/Scrap yards.

The ELV Directive [22] further provides that only Authorized Treatment Facilities (ATF) that shall meet standards as provided in the regulation are allowed to receive ELVs for treatment. It is the UK's Environmental Agency's mandate to ensure that these facilities meet the set standards. Advanced recycling and reuse of ELV waste is realised through predesigned dismantling procedures, recovery, and material processing at these facilities. In Nairobi City County, there were no such policies and guidelines existing and both the salvage firms and the ELV yards lacked equipment for shredding and processing the ELV waste. With reference to the findings on strategies adopted by the EU [26], the Salvage firms and ELV junkyards can be recommended for designation as the authorized ELV waste handlers.

The study revealed that there were no specific waste-collecting firms that dealt with ELV waste and that wastes from the garages were collected by the general waste collection firms. This implied that motor vehicle and ELV wastes are disposed of together with general waste at the dumpsite. Key informants from NEMA and the NCCG also reported that there is no designated area for disposal of ELVs. Designating Authorised Treatment Facilities (ATFs) and landfilling of non-recyclable wastes is a feasible solution to this problem.

The findings revealed that all the salvage firms and ELV junkyards did not have waste management plans in place. 12.5% of the garages assessed had waste management plans in place and separated their wastes, whereas the remaining 87.5% neither had a waste management plan nor separated their wastes. The 12.5% garages which had the plans in place were able to significantly manage various waste types and tried to apply the 3R ISWM principles. This demonstrates that the presence of a waste management plan enhances the implementation of the 3R ISWM practices. Separation of ELV waste can also be augmented through the development or adoption of predesigned dismantling procedures, which can best be used by the salvage companies receiving the written-off vehicles from insurance companies. Defra & Bis [27] provided detailed guidelines for depollution and dismantling ELVs. In addition to the use of the International Dismantling Information System (IDIS), they recommended to the Authorised Treatment Facilities (ATFs) to obtain further information on specific and suitable depollution and dismantling procedures.

The field survey revealed that 49% of the waste produced at the garages was recyclable and if there were ELV take-back incentives in place, separation and recycling of ELV waste could have been enhanced, since even without the incentives 62.5% of the garages which were assessed revealed that they sold ELV parts as used spares.

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Seventy eight percent of the respondents further revealed that a greater number of car owners preferred second-hand parts over the new ones, which was because most brand-new spare parts were more expensive and also dealers did not give warranties especially for electronic parts. This demonstrates that there is a greater likelihood of a market that prefers used parts, which can therefore be refurbished and reused. Vehicle manufacturers can consider the take-back of recyclable vehicle parts to help in cutting down the non-biodegradable ELV waste influx at the dumping sites. It was also noted that some parts were collected for recycling due to their material composition's market value when taken to the recyclers. According to Jeff & Gregory [26] some of the authorized ELV recipients dismantled vehicle parts mainly to make profits from recovery and sale of used vehicle and ELV parts. This illustrates that there is ready market for ELV parts as there are businesses which have been set up to sell these parts.

Iintegrated Solid Waste Management (ISWM) of the motor vehicle technology should entail strategies to reduce the production of waste from the source, i.e., through the manufacture of durable and long-lasting vehicle parts. By the fact that most vehicle parts imported into the Country have already been used, there is a need to regulate the importation of used vehicles and come up with incentives to encourage the purchase of new vehicles.

The local legislative frameworks should be enhanced to ensure vehicle manufacturers selling vehicles in the Country are bound by the Extended Producer Responsibility Principle similar to that provided by OECD [28]. Collection and disposal of waste should be done by specific waste collectors to facilitate for treatment and disposal of ELV waste. All the aforementioned strategies demonstrate that appropriate ELV management practices can be realized through improving legislative and regulatory frameworks, as well as providing funding to necessary authorities to create ELV Management Systems and infrastructure.

The study findings unveiled that 38% of the wastes produced from the garages were hazardous. The wastes observed to be under this class included waste oil, used engine oil filters, transmission fluid, power steering fluid, brake fluid, vehicle coolant, acid from car batteries, among other fluids, solvents, degreasers, and lubricants. The findings further showed that most of the garages collected their liquid wastes in basins, a method which was ineffective as the garage grounds were found to be significantly polluted with oil and grease negatively impacting on the soil. Only 5 garages which represented 15.6% of the total sample had concrete floors which enabled oil-water interception. 68.8% had earth floors and without oil water interceptors, implying that significant quantities of hazardous liquids are discharged into the drainage system consequently contaminating surface and underground water ecosystems. The salvage companies also had a similar setting as the normal garage, 80% were outdoor setups without concrete flooring and proper drainage for oil-water separation. They also disposed of hazardous car components such as the non-reusable vehicle batteries into bins later collected by the domestic waste handlers.

Stringent waste management policies and guidelines for the salvage companies and garages should be put in place to mitigate the associated environmental pollution. UIC Regulations [24], Class V Rule provides that a Motor Vehicle Disposal Well which is a facility that takes the form of floor drains, work sinks, or washbasins leading to dry-wells, cesspools or septic systems. These "wells receive fluids from vehicle repair or maintenance activities, such as an auto body repair shop, automotive repair shop, new and used car dealership, specialty repair shop (e.g., transmission and muffler repair shop), or any facility that that does any vehicular repair work." These rules have facilitated sufficient safeguard of underground and surface water ecosystems from hazardous motor vehicle effluents in the US.

In Kenya, the EMCA – Water Quality Regulations 2006 prohibits discharge of effluent into the environment in violation of established standards, and also states that no person shall discharge any effluent into the environment from sewage treatment works, industry, or other point sources without a valid Effluent Discharge License (EDL) issued by NEMA. Conditions such as the installation of oil-water interceptors by facilities that carry out operations that cause to oil spills are provided following the issuing of the EDL. All other garages, with the exception of those attached to fuel stations, lacked oil water interceptors. The introduction of a policy similar to UIC Regulations, 1999 would be most ideal to mitigate the impact posed by spillage of hazardous effluents.

It's high time that the auto-recycling industries are also encouraged in Kenya, similar to countries such as the US where auto recycling industries are established, with about 95% of 12 million ELVs are recycled yearly (Cruz, 2018). ELVs are one of the most recycled consumer products in Australia [29]. This is something Kenya should encourage because it will help the country's economy, create jobs, and clean up the environment.

ELVs like other technologies ought to be treated on its own, considering the current rate of importation of both new and used vehicles. The rate at which they are being purchased, wear out and disposed of is high, hence a validated cause for alarm on their handling, treatment and disposal [30-34].

Conclusion and Recommendation

The study found that Kenya and specifically Nairobi City County produce a sizable amount of ELVs annually and that ELV and automobile wastes in general were not properly managed. Additionally, it was found that there is a ready market for ELV parts, making the Extended Producer Responsibility Principle and take-back incentives possible. The study found that the management of ELV waste was not sufficiently addressed by the existing regulatory frameworks for environmental and solid

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waste management. Enforcement of the requisite laws was found to be lacking for ELV waste management. There is therefore need to develop policies and regulations on ELV waste management and enhance their enforcement. In order to realise the two principles of ISWM, recycle and reuse, it is recommended that the enforcement agencies NEMA and NCCG consider introduction of Extended Producer Responsibility in of automobile waste. There is need for more studies on the environmental impact of ELV waste in Kenya.

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