Japan Bilingual Publishing Co.

Urban Planning and Construction

https://ojs.bilpub.com/index.php/upc

RESEARCH ARTICLE

Effect of Mishandling and Vending of Used Engine Oil on the Environment, Health and Urban Planning in Kaduna Metropolis: A Call to Action for a Paradigm Shift

Shehu, P.[1*] Azi, M.B.[2] Zakka, S.D.[3] Tanimu, A.[4] Akanbi-Lawal, N.G.[5] Yakubu, A.T.[6]

1. Kaduna State Ministry of Education, PMB 2017, Kaduna, Nigeria
2. Department of Geography, School of Arts and Social Sciences, Aminu Sale Collage of Education Azare, 044, Nigeria
3. Department of Urban and Regional Planning, Faculty of Environmental Design and Management, Federal University Oye-Ekiti, 371104, Ekiti State, Nigeria
4. Department of Public Health, School of Medicine and Health Sciences, International University Bamenda, P.O. Box 444, Cameroon
5. Department of Geography, Faculty of Arts and Social Sciences, Nigerian Defense Academy, Kaduna, 800281, Nigeria
6. Center for Research and Innovation, University of Maiduguri, Maiduguri, 600104, Nigeria

ARTICLE INFO

Article history
Received: 20 September 2023
Revised: 10 October 2023
Accepted: 23 October 2023
Published Online: 27 October 2023

Keywords:
Encroachment
Paradigm shift
Pollution
Public health
Urban planning
Sustainability

ABSTRACT

This study examined the effect of mishandling and vending of used engine oil (UEO) on the environment, health, and urban planning. An evaluation of UEO handling, environmental and public health effects, spatial distribution of UEO vendors and contributing factors to choice of location, and the relationship between the vending location and the contributing factors to the choice of the location was provided. The research adopted multiple approaches including questionnaire administration, interview, observation, and application of a Global Positioning System, Geographic Information System, measuring tape, and a camera. An accidental/snowball sampling technique was viable for the study. Data collected were processed using Microsoft Excel. Descriptive and inferential statistical techniques were used. Results revealed the UEO was acquired from mechanic garages (41%) and stored in plastic containers (74%) until it was completely disposed of (91%). 52% had a hazy knowledge of the environmental effect of UEO, yet 45% rated the extent of its contamination as high. 59% were aware of its potential hazard which can get into the human body through ingestion but did not know it could get into the human body through contact with skin (74%) or breathing (61%). However, 84% wash their hands before a meal, with soap/water (67%), and change clothes after handling the used engine oil (69%). Most of the spots were located within 0-20 meters from the road (11), along the highways, occupying the metalled portion of the road, the road shoulders, setbacks, and walkways, blocking drainages and affecting the visual and aesthetic value of the environment. A larger proportion (40) revealed that visibility/accessibility guided their choice of location. Also, a low correlation coefficient of 0.32 was recorded. The study recommended the promotion of awareness programs, enforcement of environmental regulations, good hygiene practices, enforcement of standards and development regulations, and application of smart technology and big data.

*Corresponding Author:
Shehu, P.,
Kaduna State Ministry of Education, PMB 2017, Kaduna, Nigeria;
Email: shehupatrick@gmail.com

DOI: https://doi.org/10.55121/upc.v1i1.100

1. Introduction

Pursuant to the attainment of the sustainable development goals (SDGs) targets, global drift toward the promotion of sustainable urban development, maintenance of a natural environment, and ensuring healthy living has been among the top emphasis in contemporary studies [1]. Previous studies hypothesized that the natural environment encompasses the Earth's living organisms, air, soil, and water [2], and that damage to this environment affects physical development, and human health [3]. Human-related activities in a bid to utilize the earth's resources for economic and social development purposes have to a large extent been at a cost to the environment and health. For instance, the search for modernization, improved lifestyle, and economic development culminated in the emergence of a modern society that is dependent on the use of automobile vehicles and engines, which cannot operate without engine oil or lubricants [4]. Engine oil is a product from the class of base oils made by the distillation of petroleum. The engine oil reduces friction between two moving parts, playing key roles in the maintenance of vehicles, heat and power transfer. It cleanses the components of engines, and internal combustion [5]. With the increasing utilization of vehicles, the demand for engine oil rose to 11.8 billion gallons in 2017, and an expected increase of 0.5% annually [6,7]. Engine or lubricant oil is usually drained out and changed from vehicles and engines after being used for a period of two to five months. When the engine oil is drained from an engine, it is no longer clean as it has picked up materials, dirt particles, and other chemicals during engine operation [8]. The drained oil is then referred to as used engine oil.

Research has proven that used engine oil (UEO) is harmful to physical environment [9], and human health due to its high level of dangerous contaminants; more so when it is poorly handled. It has been reported that an estimated 3.8 billion gallons of used oils were collected in 2018 globally [10], and over 10 million tons of UEOs were improperly disposed of annually [11]. This is detrimental to the environment and public health because the UEO contains arsenic, cadmium, benzene, lead, magnesium, and zinc contaminants. If the oil is improperly disposed of, these contaminants can leak into the ground and wreak havoc, including damage to the soil in which crops are grown and contaminating the food chain [12]. It also depletes the ozone layer, increasing the climate crisis, negative effects on biodiversity and ecosystem, as well as human health. The UEO could eventually even make its way into waterways, contaminating them as well, thus posing a risk to aquatic organisms [13]. Epidemiological studies confirmed that human beings are at risk of exposure to toxic chemicals and heavy metals through direct contact with or consumption of contaminated food (vegetables, animals etc.) from such a polluted environment [14]. More so, the UEO poses respiratory-related problems and if it comes in contact with the eyes or skin; it triggers an allergic skin reaction or eye irritation, and a long-term effect from repeated contact. There is also a higher risk of developing skin cancer, haematological disorders, decreased erythrocyte, haemoglobin, hematocrit, and platelet levels, increased blood pressure, and eventual death [15]. By implication, the UEO if mishandled, could inadvertently decrease the quality of life for residents in cities by creating unsanitary conditions which can lead to illness, harm, or death.

With an increasing number of vehicles and supply of engine oil especially in countries where environmental regulations and legislations are not strict, the UEO has been mishandled. While this may seem unheard of in some countries it is quite a common practice in certain parts of the world [16], majorly in developing countries including Nigeria. Contamination resulting from mishandling, deliberate disposal, spilling, and leakage of UEOs is among the disturbing environmental challenges in Nigerian cities [17]. The detriment of used engine oil is not limited to environmental and health problems, indiscriminate locating of the used engine oil vending spots constitutes planning problems as well. From the perspective of urban planning, poor handling of used engine oil has implications for infrastructure and land use planning and poses aesthetic problems including urban blight, and degradation of neighborhoods. More so, the location of the used engine oil (UEO) vending spots with no planning consideration constitutes serious development problems. Even though UEO vending among others are informal economic sectors that have provided more than 70% of total employment and 30% of GDP mostly in developing countries [18], conversely, its adverse effect on the environment, human health, and urban planning is worthy of consideration. Contemporary research manifests that the challenges in cities of developing countries including, untenable physical development, high air, land and water pollution, increased traffic fatalities, jams, unsustainable transport means, and increased carbon emission are overwhelming and have continually gained global attention due to its significance to sustainable urban development [19]. Further, it was alleged that the challenges could be attributed to weak planning and environmental management.

A worrisome source of concern with the state of the natural environment, urban development, and public health is the intense mishandling of used engine oil (UEO)

by vendors and indiscriminate spatial location of spots where the UEOs are sold in the metropolitan area of Kaduna. As the name implies, the UEOVs are dealers, suppliers, or sellers of UEOs. The UEO is common at local oil vendors across the country, especially vehicles and generator owners who patronize these stores to refill or renew their engine oil, usually leaving the old, extraneous oil with vendors. Thousands of UEOVs in Nigeria operate without adhering to the environmental, health (safety), and planning regulations since the motor oil industry is relatively controlled—it has made them a burgeoning empire [20]. In the Kaduna metropolis, they are mostly seen along major roads in inexpensive shops. They set up a business mostly on the right of ways, at the most accessible links to motorcycles, tricycles, and vehicles, and can have access to other sources of UEO. Previous studies outlined various hierarchies of urban roads and right of ways [21] (see Table 1). The right of way by definition is a space provided by the Government for the road including the metalled or unmetalled portion of the road, the walkways, shoulders, and setbacks. By implication, any development found within the perimeters of the right of ways is considered an encroachment. Encroachment on the right of way like the erection of illegal/temporary structures or vending of any kind pose challenges not limited to the environment and human health, it is found to constitute wicked urban planning problems, including poor visibility due to obstruction and aesthetic value due to pollution and haphazard development [22]. Obstructions can cause interruption of traffic flow, delays, or even pose hazards like an accident to road users and a reduction in aesthetic value is consequent to the degeneration of the physical beauty of an area.

Table 1. Urban road types and reservations.

S/N0.	Road type	Reservation (in meters)
1.	Highway/Bypass	90
2.	Arterial Road	60
3.	Sub-Arterial	45
4.	Feeder	30
5.	Collector	18
6.	Residential Street	13.5
7.	Loop Street/Cul-de-Sac	9
8.	Service Lane	5-8

Source: Damina, et al. [21].

Although several countries in the world have put in place, policies and plans to manage the disposal of UEO for human safety and the protection of the environment, yet, the inappropriate handling of the UEO and the spatial spots of its vending is a common problem in many African countries [23]. Recent findings in Ouagadougou, Burkina Faso exposed the environmental pollution, and occupational health hazards owing to poor management of UEO in auto and motor repair garages [7]. The study attributed the poor management of the UEO to a lack of formal education, dearth of training on handling and disposal of used engine oil, non-use of personal protective equipment when handling the used engine oil, thumbs down in change of clothe after handling the UEO and primitive knowledge of the health and environmental impacts of UEO amongst garage workers. Similarly, studies conducted along East-West Road, Port Harcourt Nigeria, exposed the environmental pollution owing to used oil generation and its disposal [8]. The study discovered a large proportion (60%) of automobile mechanics dispose of used oil on the land despite a significant number of them being aware of its environmental effect. Also, research carried out in Ibadan, Nigeria, examined the impact of Informal Auto-Mobile Mechanic Workshops Activities on Groundwater Quality [24]. The study exposed a high degree of groundwater contamination due to poor disposal of used engine oil leading to poor water quality in the study area. Research conducted on the violation of development control provisions by public and semi-public developers along Kachia Road, Kaduna metropolis, identified developments along the Kachia Road reservation with emphasis on public and semi-public developments and exposed the principal violators of encroachment along the Kachia Road reservation to be government institutions and private entities [21].

There are agencies established by Federal and State Governments to regulate the environmental and urban planning problems. In Kaduna State for instance, Kaduna Environmental Protection Agency (KEPA) and Kaduna State Urban Planning and Development Authority (KASUPDA) were established with the sole responsibility of regulating environmental and urban planning problems, yet UEO vending is increasingly occurring, taking over road reservation. In the year 2020, the Kaduna state government through KASUPDA embarked on urban renewal projects to address the rising urban development challenges in the metropolis of Kaduna. Among the projects, one proposed relocating of all motor mechanics from the metropolis to six designated mechanic villages at the outskirts of the city to reduce the incidence of repairing broken-down vehicles on major roads. The proposed sites were located in Millennium City, Kachia Road, and the railway station area of Rigasa, Zaria Highway, Birnin Gwari Highway, and Abuja Highway [25]. Upon commencement of the project, about 150 motor mechanics were reportedly displaced by demolition. Three years down the lane no efforts have been initiated to provide a working place for the displaced motor mechanics, as there

is no visible development at the proposed site. While the effort to relocate the mechanic garages within the city has failed, little or no effort has been made to address the activities of the UEOVs. These activities are seemingly not regulated and monitored owing to indiscriminate locating and mishandling or wrong disposal of UEOs which has become a daily routine [26]. This requires superior attention owing to its potential to cause serious harm to the environment, human health, and urban development.

Several studies have examined the management of lubricant or used engine oil and development along road reservations in the clamour for environmental sustainability, public health and safety and promotion of sustainable urban development predominantly in developing countries (Table 2).

Table 2. A summarized review of relevant literature.

Article	Aim and methods used	Summary of findings
[8]	The study assessed the generation and disposal of used-oil along East-West Road, Port Harcourt Nigeria. Structured questionnaire and one-on-one interview was applied to collect data.	It was discovered, used engine oil in some automobile mechanics was disposed of on the land, some sell it, and others reuse it. Also, a large proportion were aware about recycling of the used oil, few claimed ignorance while others did not see the need for recycling. On storage method, majority do not store used oil.
[27]	The study investigated the volume and disposal methods of spent automobile engine oil generated at Nekede Mechanic Village in Owerri, Imo State Nigeria. Structured questionnaire, personal interviews and field observations was used to collect data.	Over 1.4 million liters of spent engine oil was produced annually in the mechanic village. Mostly, disposed spent engine oil on the soil, within their immediate environment, while others used it for other purposes, such as pest control, sharpening of blades and reuse in heavy trucks among others.
[28]	The study investigated the used oil storage and disposal practices in automobile repair garages in Ghana. Data were collected using questionnaire, observations and personal discussions.	They discovered a very large proportion of the auto repair garages in the country lack storage and disposal standards. Also, there was no training programs to educate and sensitize the mechanics about the health and environmental hazards of used oils.
[29]	The study investigated the generation, use and disposal of waste crankcase oil in Kampala district, Uganda. An in-depth interview was used in data collection.	Most garages and fuel stations offered oil-changing services. On average, each garage produced 62 liters, and each fuel station produced 134 liters of waste crankcase oil per week. Uses of waste crankcase oil included coating roofing timber and fencing posts, use in timber cutting, marking play grounds, and pest control in animals. Its disposal involved burning, and pouring in the environment.
[30]	This study aimed to assess differences in blood pressure and hematological parameters among garage workers compared to the Haramaya University community, Harar, eastern Ethiopia. Data were collected by the use of a structured Questionnaire, shygmomanometry, and hematology analyzer.	The majority of the garage workers did not implement effective preventive or control measures for workplace chemical exposure. Thus, there were significant differences in blood pressure and hematological parameters between garage workers and the control group.
[31]	The study assessed the effects of spent engine oil on hematological parameters, renal and liver status of auto-mechanics. A questionnaire was design and blood sample was collected from both auto-mechanics and non-mechanics.	The result revealed complaints of pains around thoracic region, skin, rashes etc; unawareness of the detrimental contents of spent engine oil; poor precautionary and sanitary practices. Assessment of renal status indicated that plasma urea and creatinine levels for auto-mechanics (18 mg/dL and 0.81 mg/dL, respectively) were significantly higher compared to non-mechanics (16 mg/dL and 0.68 mg/dL, respectively).
[21]	The study identified developments along the Kachia road reservation with emphasis on public and semi-public developments. The study utilized field observation and secondary data to collect data.	It was discovered that government institutions and corporate private organizations were the principal violators of encroachment along the Kachia road reservation.

Based on the summary in Table 2, several interesting conclusions could be drawn from the literature review. First, the studies established significant findings on the management of used engine oil and how it has impacted negatively certain parts of the environment; however, the previous studies concentrated majorly on mechanic garages which is one sector in the generation and handling of UEO. Used engine oil vendors are equally a sector in the handling of UEO which have seemingly contributed adversely to contamination of the environment, disruption of physical development and compounded health problems. To the best of the researcher's knowledge, this sector has not been considered in the region of Nigeria, and Africa at large. Secondly, the previous studies employed great techniques in collecting data. However researching the management of UEO and its implications in the environment using research techniques like structured questionnaires, interviews, observation, and discussions is not enough. There is the need to identify these areas spatially on maps using techniques like GIS, GPS, and AutoCAD, among others and application of models to ascertain the significance or degree of correlation of attributes that influenced the operation of the UEO handlers in the established locations. This enables prompt action by decision-makers. Motivated by these deficiencies, the present study addressed critically the research gaps. The current study is also prompted by a call to action for a paradigm shift; the need for a fundamental change in handling and vending of used engine oil.

The importance of promoting sustainability in our environment, in health and urban development cannot be continually over-emphasized. It contributes to the protection of natural resources, biodiversity, ecosystems and mitigating climate change [32,33], and improves human health by lessening exposure to contaminants and detrimental substances, reducing the risk of diseases and advancing overall well-being. Sustainability fosters resilience to climate change, social equity and the establishment of livable cities [34]. Sustainable urban development leads to economic growth and affluence such that a well-planned and developed city attracts businesses and investments. Enhancing a sustainable environment and urban development facilitates communities to adapt and become more resilient to its impacts. More so, sustainable practices such as efficient resource use, renewable energy adoption, and climate-responsive planning can mitigate hazards and shield communities from climate change [35]. Also, sustainable urban development creates inclusive and equitable communities, fosters social cohesion and enhances quality of life [36]. The aforementioned importance of promoting sustainability in the various areas considered in this research (environment, human health and urban development) is proof of why this study is significant and timely considering the state of the metropolis. The research is beneficial to the government and stakeholders in Nigeria's environmental, health, and development control agencies. Also, it adds to the body of knowledge globally and provides the basis for further studies. Internationally, it provides room for intervention through investments and assistance to address the disturbing threat.

Based on the foregoing, this study examines the menace and reckless handling of UEO by local vendors and the spatial location of this activity in the Kaduna metropolitan area. The selected objectives of the research include an evaluation of UEO handling, an examination of the environmental and public health effects, an evaluation of the spatial distribution/location of UEOV shops and contributing factors to the choice of the location, and examination of the relationship between the UEO vending location and the contributing factors to the choice of the location.

2. Materials and Methods

2.1 Study Area

Kaduna metropolis is the capital of Kaduna State, located on the southern end of the high plains of Northern Nigeria, gridded by 10°20' N and 10°37' N of the Equator and Longitudes 7° 22' E and 7°31' E of the Greenwich meridian with the elevation ranging from 600 to 650 m above mean sea level [37]. The study area is firmly drawn around developed areas of the metropolis. The metropolis cut across four Local Government Areas (LGAs), encompassing Kaduna North, and Kaduna South, as well as parts of Chikun and Igabi LGAs of Kaduna state, and has about 12,347 km^2 land mass (Figure 1). It is largely drained by River Kaduna which divides the metropolis into two parts. The main tributaries of the river are rivers Romi and Rigasa. Historically, the Kaduna metropolis is founded on three firm bases legs: Administrative Capital, Industrial Town, and a Military Garrison. The city is among the leading industrialized and sub-national economies in Nigeria. Generally, it is a gateway between Southern Nigeria and other parts of the North. Thus, it provides an essential platform for the transportation of food supplies and other goods to various parts of Nigeria and other countries, such as Niger, Cameroun, Benin, and Ghana. Presently, the metropolis has over 80 commercial and industrial firms that manufacture several products [38]. The climate is predominantly influenced by the relatively warm and moist tropical maritime air masses. These air masses meet along

a slanting surface called inter-tropical discontinuity (ITD). The movement of the ITD northwards across the northern part of this zone in August (around latitude 21°-22°N) marks the height of the rainy season in the whole zone while its movement to the southernmost part around January/February (approximately at 6°N) marks the peak of the dry season in the zone with annual mean rainfall from 1,016 mm to 1,524 mm [39]. The metropolis is covered by savanna vegetation consisting of Guinea savanna, Sudan savanna, and Sahel savanna with the density of trees and other plants decreasing as one moves northwards [39]. Based on the World Population Review [40], the Kaduna metropolis currently housed an estimated population of 1,776,072 with a 3.33% annual change.

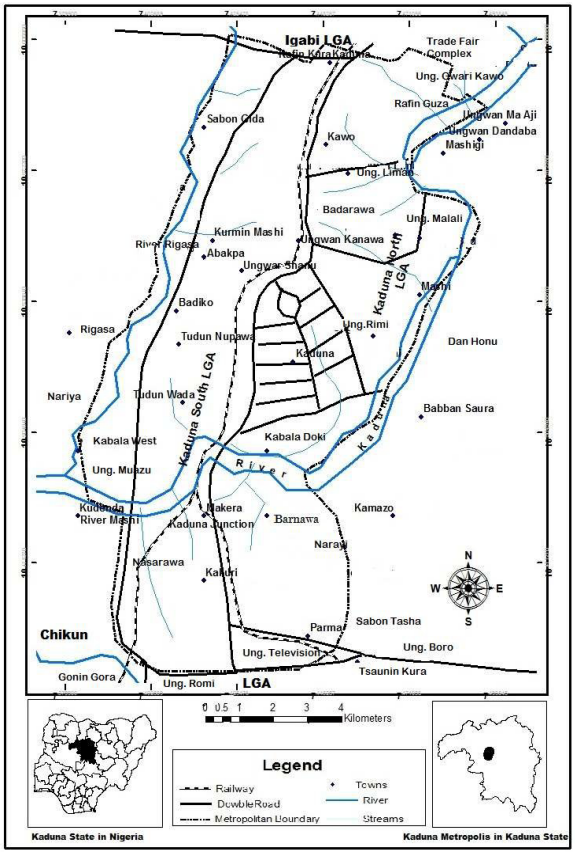

Figure 1. Location of Kaduna metropolis.

Source: KASUPDA.

2.2 Data Requirement, Sources, and Method of Collection

The data for this study involved handling of the UEOs at vending spots, environmental and public health hazards of the UEO, spatial distribution/location of vending and the contributing factors to the choice of spots. Satellite imagery scene of Kaduna for the year 2022 and map of the metropolis were equally sought. Data for this study were obtained from primary and secondary sources. The secondary sources were the data acquired from relevant kinds of literature and official documents (map of the metropolis, Kaduna state, and Nigeria obtained from KASUPDA) including the acquisition of high-resolution satellite imagery from Google Earth Engine. The primary data were acquired through the administration of structured questionnaires strictly to sampled UEO vendors including face-to-face interviews, field observations, objective measurement of the UEOV spots from the road, recording of coordinates for geo-referencing, mapping and photographs recordings using devices including a measuring tape, a global positioning system (GPS), geographic information system (GIS) specifically ArcGIS 10.5 software, and a camera.

2.3 Sampling Procedure, Sample Size, and Data Analysis

The target population of this study was mainly UEOVs. Accidental/snowball sampling techniques were viable for the study. Four foremost UEO vendors in four local governments that made up the Kaduna Metropolis were randomly selected to form the first sampled population. There were 1st, 2nd, and 3rd referrals for questionnaires to be administered to three randomly selected respondents. Five questionnaires were administered per LUEOV spot, forming a sample size of eighty (80). The retrieved questionnaires were processed using Microsoft Excel, from which, seventy-two (72) were valid (Table 3). Subsequently, the valid data were successfully analyzed using descriptive and inferential statistical techniques. Similarly, data obtained from GPS and Google Earth Engine were processed in the ArcGIS 10.5 software yielding a map elucidating spots of the local used engine oil vendors surveyed (Figure 4).

Table 3. Administered questionnaires to the selected LUEVs.

LGAs	Selected LUEOV spots	Questionnaires administered	Valid
Chikun	4	20	20
Igabi	4	20	17
Kaduna North	4	20	16
Kaduna South	4	20	19
Total	16	80	72

Source: Author's field work.

2.4 Model Specification

In this research, a multiple correlation model was

employed to examine the correlation between the UEO vending location and the contributing factors to the choice of the location. This model ascertains the degree of association or relationship of the variables or attributes. The relationship examined was therefore between the spatial location of the used engine oil vendors and the factors that influenced the choice of the vending spots. The values of the correlation coefficient and the nature of the relationship or association are revealed in Table 4.

Table 4. Correlation coefficient and the nature of relationship or association.

S/N0	Correlation coefficient	Nature of relationship
1	0.00 to 0.30 (0.00 to –0.30)	Little or no correlation
2.	0.3 to 0.50 (–0.30 to –0.50)	Low positive (negative) relationship
3.	0.50 to 0.70 (–0.50 to –0.70)	Moderate positive (negative) correlation
4.	0.70 to 0.90 (–0.70 to –0.90)	High positive (negative) correlation
5	0.90 to 1.0 (–0.90 to –1.0)	Very high positive (negative) correlation

Therefore, the correlation model is assumed as follows:

$$Cell\ ij = \frac{ith\ Raw\ Total\ X\ jth\ Columm\ Total}{Grand\ Total} \quad (1)$$

$$x^2 = \sum \frac{(O-E)^2}{E} \quad (2)$$

$$r = \sqrt{\frac{x^2}{N(k-1)}} \quad (3)$$

where,
i = the i^{th} raw; j = the j^{th} column; x^2 = chi square; O = observed value;
E = expected value; r = correlation coefficient; N = grand total of participants;
k = raws/columns.

2.5 Limitations

There was low cooperation by some UEO vendors owing to suspicion that the researchers were Government agency who were on a mission to map out UEO vending locations to be demolished, like the case of mechanic garages. Thus, some of the respondents were hostile and not cooperating. Some refused to be interviewed, and warned not to take photos or record any information as per their location; some were not found at their vending spots; yet, it was pertinent to wait until they were around. This caused so much delay and time wasting. Another challenge encountered was that some questions were skipped and some especially the two option questions (Yes or No) were both ticked. These irregularities led to the annulment of eight questionnaires.

3. Results

3.1 Handling of the UEO

Handling of UEO was determined and as elucidated in Table 5; 41% of the respondents admitted they acquire the used engine oil from mechanic garages, 29% collect from filling stations, while 19% source it from vehicle owners who usually change their vehicles' engine oil periodically and 11% acquire from industries and construction companies. Regarding storing it after collection, 74% store the UEO in plastic containers or cans until it is completely disposed of, and some (23%) store it in metal drums or tanks, and leather sacks, as attested by 3% (Plate 1). Concerning handling or disposal of the product, 91% indicated selling to end users being the primary reason for their involvement in the UEO business.

Table 5. Collection, storage and handling of UEO.

Variables	Frequency	Percentage
Collection point		
Mechanic garage	30	41
Vehicle owners	14	19
Filling station	20	29
Industries/Construction companies	8	11
Storage facilities		
Plastic containers/cans	53	74
Metal drums/tanks	17	23
Leather sacks	2	3
Handling/Disposal		
Sell to end users	66	91
Deliberately poured on land (dust suppressant)	5	7
Accidental discharge (spilling/leaking)	1	2
Total	72	100

3.2 Environmental and Public Health Effects of UEO

The knowledge about the UEO contamination of the environment was also investigated. The survey revealed that 52% of the respondents did not have any such knowledge, 39% knew about it and 9% did not respond (Figure 2). The survey further revealed the extent of environmental contamination in the various UEO vending spots visited, 45% of the respondents showed the extent of contamination was high, 39% revealed it was moderate and 18% indicated low impact (Figure 3 and Plates 1A/1B).

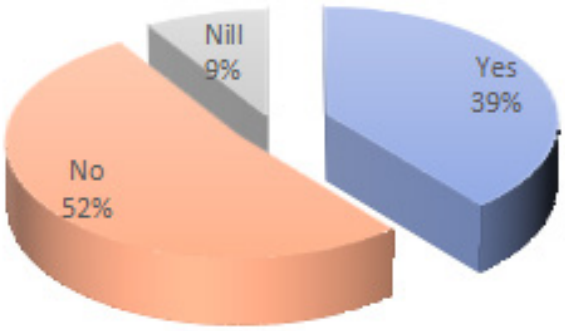

Figure 2. Knowledge of the environmental effect.

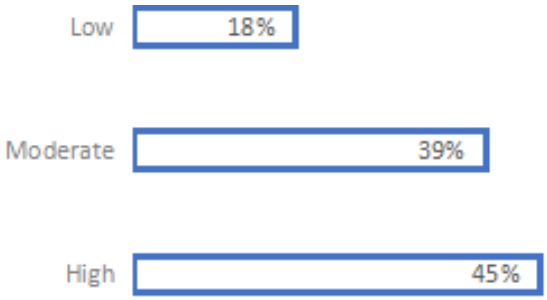

Figure 3. Extent of environmental contamination.

(A) (B)

Plate 1. Mishandling of UEO as it contaminates the environment and humans.

The survey on the effect of UEO on human health presented in Table 6 shows that 59% were aware of the potential hazards of UEO on human health which can get into the human body through ingestion (63%) but were not aware it can affect human health through contact with skin (74%) or breathing (61%). The survey also revealed that 93% of the respondents didn't use safety kits when they were handling or disposing of the UEO, although they wash their hands before a meal as revealed by 84% which they usually use soap and water (67%) or use fuel, soap, and water (33%). A Significant proportion of the respondents (69%) revealed they change clothes after handling the UEO and 63% assured they do not have a health problem (Plates 1A and 1B).

Table 6. Responses about UEO effect on public health.

Variable	Response	Frequency	Percentage (%)
UEO has an effect on human health	Yes	42	59
	No	30	41
The UEO can get in the body via ingestion	Yes	45	63
	No	27	37
It can get in the body via skin.	Yes	19	26
	No	53	74
It can get in the body via the means of breathing.	Yes	28	39
	No	44	61
Use of safety kit when handling UEO	Yes	5	7
	No	67	93
I wash hand before a meal	Yes	60	84
	No	12	16
I wash hand with: (A) Soap and water, (B) Fuel, soap, and water	A	48	67
	B	24	33
I change clothes after handling UEO	Yes	50	69
	No	22	31
I have some health challenge	Yes	27	37
	No	45	63

Source: Author's field work.

3.3 Spatial Distribution/Location of UEOV Shops and Contributing Factors to Choice of the Spot

It was observed that all the sampled UEOV spots were along Highways/Bypass including Maraban Rido to Gonin Gora, Nnamdi Azikiwe Way, Birnin Gwari Way, Kaduna-Zaria Way, and Millennium City Way; Arterial Road, specifically Command Junction to Stadium roundabout, and Dan Musa feeder road around Ori Apata. This section of the study sought to determine the extent of encroachment on road reservations by recording the distance of the sampled UEOV spots from the road and mapping to determine the spatial distribution of the spots. It was discovered that a huge proportion (11) were within 0 to 20 meters from the road; these were found majorly along Nnamdi Azikiwe expressway, Dan Musa feeder road around Ori Apata, Gonin Gora, Kachia, and Birnin Gwari road. Four (4) were spotted within 21 to 40 meters, mainly along Millennium City Express, Yakowa Way and Command Junction. Yet, one (1) was spotted within 41 to 60 meters, along the Kaduna-Zaria expressway (Figures 4 and 5). All the sampled UEO vendors were spotted on the metalled portion of the road, on road shoulders, setbacks, walkways, and on drainages, implying encroachment on the road reservations (Plate 1B, 2A/2B, and 3).

On factors contributing to the choice of vending spot, a great proportion (40), revealed that visibility and easy access by customers was their motivating factor while 25 and 7 respondents opted for a higher number of customers and proximity to sources of the UEO (Table 7).

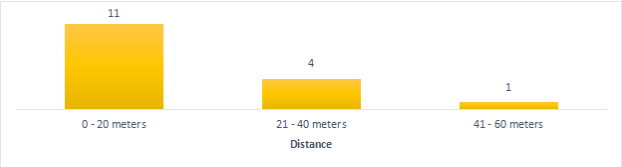

Figure 4. Distance of the UEOVs from the road.

Table 7. Contributing factors to choice of UEO Vending spot.

Factors	Frequency	Cumulative frequency
Visibility/Accessibility	40	40
Customer demography	25	65
Proximity to sources of UEO	7	72

3.4 Correlation Analysis

As stated previously, the purpose of this analysis is to ascertain the degree of association between the UEO vending location and the contributing factors to the choice of the location. Based on the result, a 0.32 correlation coefficient (r) was recorded, implying a low positive correlation between the UEO vending location and the contributing factors to the choice of the various vending spots. It also means that variation in change of the vend-

ing location does not influence or affect the UEO vending business in terms of visibility and accessibility, increased number of customers (customer demography), and proximity to sources or collection points (Tables 8-10).

(A) (B)

Plate 2. UEO vending on the metalled portion of the road and walkway.

Plate 3. UEO vending on the road shoulder.

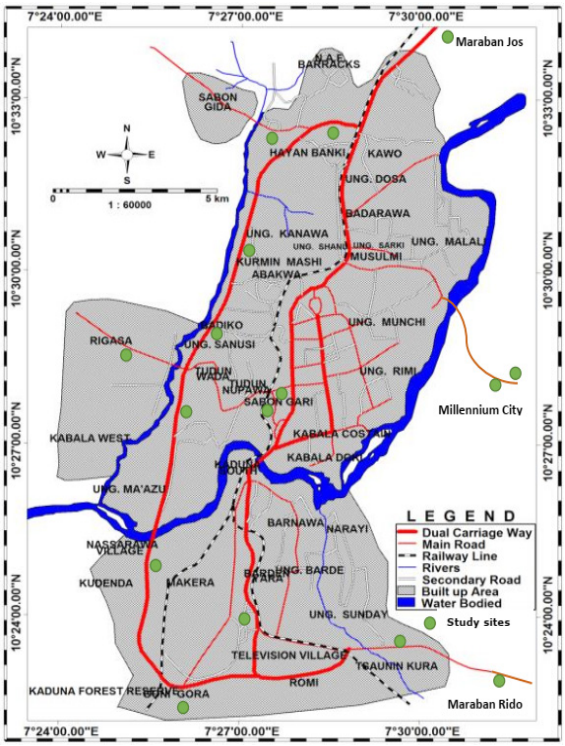

Figure 5. Local used engine oil vendor spots surveyed.

Table 8. Observed value.

Contributing factors	Distance of vending spots from road (in meters)			Total
	0-20	21-40	41-60	
Visibility/Accessibility	33	6	1	40
Customer demography	17	5	3	25
Proximity to sources of UEO	1	4	2	7
Total	51	15	6	**72**

Table 9. Expected value.

Contributing factors	Distance of vending spots from road (in meters)			Total
	0-20	21-40	41-60	
Visibility/Accessibility	28.33	8.33	3.33	40
Customer demography	17.71	5.21	2.08	25
Proximity to sources of UEO	4.96	1.46	0.59	7
Total	51	15	6	**72**

Table 10. Computation of the correlation coefficient.

O	E	O – E	$(O - E)^2$	$\frac{(O - E)^2}{E} = x^2$
33	28.33	4.67	21.81	0.77
6	8.33	–2.33	5.43	0.65
1	3.33	–2.33	5.43	1.63
17	17.71	–0.71	0.50	0.03
5	5.21	–0.21	0.04	0.01
3	2.08	0.92	0.85	0.41
1	4.96	–3.96	15.68	3.16
4	1.46	2.54	6.45	4.42
2	0.59	1.41	1.99	3.37
72	72			14.45

Note: Therefore, correlation coefficient (r) is 0.32.

4. Discussion

The study found that the UEO was acquired mostly from mechanic garages and filling stations; others were collected from vehicle owners and industries/construction companies. This could be associated with a large number of commercial, private, government, and diplomatic vehicles found in the Kaduna metropolis [41], and the presence of over 80 commercial and industrial firms that manufacture textiles, aluminum, dairy products, toiletries, and petroleum products [33]. The high number of vehicles implied more generation of UEO. The UEOs were stored mostly in plastic containers or gallons until it is sold completely to end users. Selling to end users was primarily the purpose of the business, yet a significant volume of the UEO ends up in the surrounding environment because some vendors used it as dust suppressants and most times accidentally disposed of directly on land due to spilling or leaking from vehicles or storage facilities as some of the containers were observably weak and had a tendency of leaking (Plates 1 and 2). Similar circumstances were observed in Poland [13], Ghana [28], and Burkina Faso [7]. The studies observed that storing UEO creates a fire or environmental hazard. It is also dangerous to store used oil in containers for long periods. Many materials can degrade when in contact with UEO, increasing the risk of a spill. In the present study inappropriate disposal of UEO into open lands and drains suggests potential entry routes into the environment causing soil, surface, and groundwater contaminations.

On environmental contamination, a large number of the UEOVs had little or no knowledge of its potentially adverse environmental impacts but admitted they were aware that it affects the soil only with a larger proportion rating the extent of soil contamination, as high. This was further confirmed through observation, the inappropriate

handling of the UEO at the various spots visited including disposal of the UEO within the surrounding vicinity, spraying on roads as a dust suppressant, protecting timber pillars and walls from termites, spraying in pit latrines to reduce bad odour, and a portion of it been disposed of in close-by drains. This result agrees with the work [8], which reported that most of the UEOs are thrown into the environment. According to the findings [17,7], the disposal of UEO in the environment affects the soil negatively due to increased soil bulk density and reduced gravimetric moisture content, total porosity, and hydraulic conductivity. Oloruntoba, E.O. et al. [24] found that UEO contamination affects groundwater quality and plants.

Regarding the effect of UEO on human health, a predominant number were aware of its potential hazard which can get into the human body via ingestion but had no knowledge it can affect the human body through contact with skin or breathing. This explains why most of the UEOVs don't use safety kits when dealing with the UEO, even though they wash their hands with soap and water or fuel, soap, and water before meals and change clothes after the close of business. It was observed the UEOVs hardly changed their clothes after coming in contact with the UEO. This demonstrates their hazy awareness of the detrimental contents of UEO. The findings agree with [30], in which automobile workers in Ethiopia were discovered not applying preventive measures and were not following safety measures. Furthermore, workers had a habit of smoking, drinking, and eating at the garage where the used oil was kept, further increasing their chance of ingesting the used oil. The route of penetration of toxic substances from UEO into the human body is not limited to ingestion; respiration and contact with the human skin are other major means. UEO gets through the respiratory tract, causing changes in the lungs, liver, kidneys, adrenal glands, and heart [31]. It is also absorbed by the skin, causing significant health consequences including irritant and allergic reactions. Likewise, frequent and prolonged contact with UEO may cause dermatitis and other skin disorders, including skin cancer, rashes, and blood pressure. A risk analysis conducted in Ethiopia discovered that more often and inordinate exposure was strongly connected with a greater incidence of symptoms, and that lack of protective kits and awareness was positively linked with acute adverse health effects [30]. Additionally, the manifestations most often reported in people exposed to UEO are respiratory defects, back pain, headache, and neuro vestibular disorders.

On the spatial distribution/location of the used engine oil vending spots and the contributing factors to the choice of spot; it was observed that a larger number of UEO vendors were spotted along Nnamdi Azikiwe bye passway and Gonin Gora to Kachia road. This could be due to its strategic nature being the major entrance to and exit of the metropolis. As such, the roads have been congested and virtually taken over by informal activities including UEO vending. It was also observed, that a larger number of the UEO vending shops were constructed temporarily consisting of small containers, zinc, and wooden frames. Most of the vendors were spotted within 0 to 20 meters from the road, taking over the walkways, road shoulders, setbacks, and on drainages, and some encroached into the metalled portion of the roads. The implications of these unchecked activities include encroachment on road reservations and reduction of road size leading to narrowness. This result confirmed the study conducted along Kachia Road in Kaduna Metropolis [21], where the roads that were originally designed for single-purpose use were occupied by numerous informal activities. Vending on road reservations has a grievous effect on urban development spanning the problems of congestion, traffic conflicts, accidents, and obstructions consequent to poor location of the vending spots. The erection of temporary UEO vending shops on the road reservations was observed to reduce the visibility and aesthetic value of the environment. Illegally dumped or improperly stored used engine oil can create visual blight in urban areas, negatively impacting the aesthetic appeal of transportation corridors and public spaces. This can undermine efforts to create attractive and livable communities. It was also found to pollute the surrounding areas with undesirable odour. Some spots were sited on the road thereby reducing the width of the road, deteriorating the road surface, and causing safety concerns by forcing pedestrians to walk on the road and in-between traffic (Plates 2A and 2B).

Investigating the factors that may have contributed to the vendor's choice of location, it was revealed mostly that visibility and easy access by customers strongly influenced their decision, while others stated customer demography and proximity to the UEO collection point as their motivating factors. This could be true owing to the economically strategic nature of the highways in the metropolis coupled with a perceived assumption that establishing a UEO business on these strategic roads attracts customers and generates high revenue.

To examine the relationship between the extent of the association between the UEO vending location and the contributing factors to the choice of the location, a correlation coefficient (r) of 0.32 was recorded indicating a low positive correlation between the examined variables. By implication, the used engine oil vendors can easily be relocated to a different and suitable location in line with

urban planning considerations. This analysis provides valuable insights to policymakers in making informed decisions about the optional location for local used engine oil vendors and prompt handling of the UEO. If used engine oil is not handled aptly, it can leak onto road surfaces, causing pavement degradation and reducing the lifespan of transportation infrastructure. Repairing and maintaining damaged infrastructure can be costly and disrupt transportation networks. Also, spilled UEO can create slippery road conditions, increasing the risk of accidents and injuries for motorists, cyclists, and pedestrians; it can accelerate the deterioration of the surface material. This can lead to cracks, potholes, and reduced road lifespan, requiring more frequent repairs and maintenance. Safe urban development must consider these challenges and prioritize measures to prevent such occurrences.

5. Conclusions

This research exposed the negative effects of mishandling and vending of used engine oil on the immediate environment, human health, and urban development, mostly the used engine oil (UEO) vendors. This was achieved through an evaluation of UEO handling, an assessment of the environmental and public health effects, an evaluation of the spatial distribution/location of UEOV shops and contributing factors to the choice of location, and an examination of the relationship between the UEO vending location and the contributing factors to the choice of the location. The research adopted multi-dimensional approaches. The results of this study show that the handling of UEO in the Kaduna metropolis does not comply with environmentally sustainable measures. This can be detrimental to the environment, human health and physical development. Thus, the government and concerned stakeholders must rise to the challenge of providing a comprehensive information base, addressing UEO-related activities and regulating its handling, collection, use, constituents, environmental, health, and development vulnerabilities. The existence of UEO vendors within the perimeters of the right of way of the various roads in the Kaduna metropolis poses serious development problems. This points toward weak enforcement of development control and adherence to development guidelines by developers and therefore, calls for the need for development control authorities to ensure strict compliance to canons of development control and frown at any unsustainable development on road reservations. This will not only enhance the visual quality and beauty of the environment but will ensure accessibility and functionality of major routes and foster economic development. This is based on the fact that a smart, secure and orderly environment attracts more economic investment that benefits the generality of people and promotes national development.

Given the findings of this study, recommended actions that should be taken towards a paradigm shift to promote sustainable handling and vending of used engine oil have been made:

There is a need for the inclusion of handling and vending of used engine oil in the environmental awareness program and establishment of proper collection/disposal systems. This involves setting up collection points in different areas of the city where individuals can drop off their used oil. It is important to ensure that these collection points: Conduct public awareness campaigns and educational programs to inform individuals about the environmental impact of improperly disposing of used engine oil. Emphasize the importance of recycling and reusing oil to reduce pollution.

There should be legislation to stop the indiscriminate disposal of UEO on the surface of the soil at vending spots through the development of regulations and guidelines. Applying stern regulations and guidelines for the handling, storage, transportation, and disposal of used engine oil goes a long way towards a friendly and sustainable environment. These regulations should address issues such as labeling, packaging, and safe transport to ensure that oil is handled properly at all stages.

There is a need for UEO handlers to observe good hygiene practice of keeping their kits, work clothes, and environment as neat as possible. Avoid unnecessary contact with UEO. Washing of hands should be made a regular practice, and embrace safe systems of work, wear protective clothes which should be washed or replaced frequently. Do away with oily rags in pockets as the oil will seep through overalls and affect the skin below. The use of face masks and eye-glass should equally be encouraged to protect the eyes, nose, and mouth, as well as prevent the passage of UEO through these channels into the body. Again, individuals who are regularly involved in handling and using UEO should visit health centers and clinics for regular checkups.

The Zonal Controller of Works in collaboration with KASUPDA and KadGIS should improve development control guidelines, discourage corrupt practices and promote professionalism. This can be achieved through the establishment of an ad-hoc committee, charged with the responsibility of ensuring strict compliance with the established planning laws at the state level and the engagement of more professionals in relevant fields. Immediate action should be taken when a violation is identified to prevent encroachment at an early stage and control development on road reservations.

Encourage the use of big data and smart technology like machine learning. This can be helpful when it comes to identifying planning problems in an urban environment. Various cameras and sensors dotted across an urban area assist planners in detecting problems and knowing exactly where development may be best placed. From making the most use of space to mitigating development problems, big data can help urban planners make more efficient environments.

Author Contributions

Patrick Shehu reviewed the environmental and urban planning aspects of the literature, conceptualized the work, designed the procedures for carrying out the research, produced maps, carried out investigations, data curation, analysis and interpretation of the data, and prepared the original manuscript text. Musa Bulus Azi and Solomon Dyachia Zakka, contributed during data curation, interpretation of the result and editing of the drafted manuscript. Alheri Tanimu reviewed the health related literature, assisted in data analysis and interpretation. Nuhu Gbemileke Akanbi-Lawal and Ayaka Taimako contributed financially at the point of investigation and data curation, and edited the drafted manuscript.

Conflict of Interest

The authors declare no conflict of interest.

Funding

This work received no external funding. Funds and resources were mobilized by researchers.

Acknowledgement

The authors are immensely grateful to the study participants (UEOVs in Kaduna Metropolis) for their understanding, support, and compliance during the fieldwork. Mr. Barde Runtumi Danjuma (aka Anda), Mr. Benjamin Yaki, and Mr. Godiya Yaro are not left out for their unflinching logistics support while collecting the data for this research. All secondary data including the literature are duly acknowledged.

References

[1] Shehu, P., Rikko, L.S., Azi, M.B., 2023. Monitoring urban growth and changes in land use and land cover: A strategy for sustainable urban development. International Journal of Human Capital in Urban Management. 8, 111-126.
DOI: https://doi.org/10.22034/IJHCUM.2023.01.09

[2] Papakonstantinou, E., Mitsis, T., Dragoumani, K., et al., 2021. Materials of biological origin and biofuels: Small environmental footprint and epigenetic impact. International Journal of Epigenetics. 1(3), 1-8.
DOI: https://doi.org/10.3892/ije.2021.6

[3] Ajah, F.O., Osuji, J.O., Anoliefo, G.O., 2019. Genotoxicity and environmental implications of crude oil-related pollutants in Nigeria. Asian Journal of Advanced Research and Reports. 4(1), 1-12.
DOI: https://doi.org/10.9734/AJARR/2019/v4i130103

[4] Nissar, A., Hanief, M., Mir, F.Q., et al., 2022. Experimental assessment of recycling methods of used engine oil for sustainable environment. Research Engineering Structures Materials. 8(3), 553-567.
DOI: http://dx.doi.org/10.17515/resm2022.385ma0113

[5] Ratiu, S.A., Tirian, G.O., Mihon, N.L., et al., 2022. Overview on globally applied used engine oil recycling technologies. IOP Conference Series: Materials Science and Engineering. 1220(1), 012034.
DOI: https://doi.org/10.1088/1757-899X/1220/1/012034

[6] Pinheiro, T.C., Quina, J.M., Gando-Ferreira, M.L., 2021. Management of waste lubricant oil in Europe: A circular economy approach. Critical Reviews in Environmental Science and Technology. 51(18), 2015-2050.
DOI: https://doi.org/10.1080/10643389.2020.1771887

[7] Naré, R.W., Tienoupagri, A.S., Sawadogo, T.C., et al., 2019. Management of used engine oil in auto and motor repair garages in Ouagadougou, Burkina Faso. International Journal of Advanced Research. 7(11), 652-658.
DOI: http://dx.doi.org/10.21474/IJAR01/10054

[8] Zitte, L.F., Awi-Waadu, G.D.B., Okorodike, C.G., 2015. Used-oil generation and its disposal along east-west road, port Harcourt Nigeria. International Journal of Waste Resources. 6(1).
DOI: https://doi.org/10.4172/2252-5211.1000195

[9] Salih, N., Salimon, J., 2021. A review on eco-friendly green biolubricants from renewable and sustainable plant oil sources. Biointerface Research in Applied Chemistry. 11(5), 13303-13327.
DOI: https://doi.org/10.33263/BRIAC115.1330313327

[10] Islam, M.S., Sanzida, N., Rahman, M.M., et al., 2021. From the value chain to environmental management of used lube oil: A baseline study in Bangladesh. Case Studies in Chemical and Environmental Engineering. 4, 100159.
DOI: https://doi.org/10.1016/j.cscee.2021.100159

[11] Wright, C., 2021. The Environmental Significance of Sustainable Lubricants [Internet]. Available from: https://www.azocleantech.com/article.aspx?Arti-

cleID=1198#

[12] Lourenço, S.C., Moldão-Martins, M., Alves, V.D., 2019. Antioxidants of natural plant origins: From sources to food industry applications. Molecules. 24(22), 4132.
DOI: https://doi.org/10.3390/molecules24224132

[13] Wolak, A., Fijorek, K., Zając, G., 2020. Professional car drivers' attitudes toward technical, marketing and environmental characteristics of engine oils: A survey study. Energies. 13(8), 2069.
DOI: https://doi.org/10.3390/en13082069

[14] Deziel, N.C., Brokovich, E., Grotto, I., et al., 2020. Unconventional oil and gas development and health outcomes: A scoping review of the epidemiological research. Environmental Research. 182, 109124.
DOI: https://doi.org/10.1016/j.envres.2020.109124

[15] Basu, R., Biswas, A., Biswas, K., et al., 2015. An attempt to search the health status of garage workers: A neglected part in India. International Journal of Advanced Research. 3(7), 1466-1471.

[16] Shah, R., Braff, S., Nagarkoti, B2.S., 2019. Lubricants and the Environment [Internet]. Available from: https://www.petro-online.com/article/analytical-instrumentation/11/koehler-instrument-company/lubricants-and-the-environment/2574

[17] Johnbosco, U., Chimezie, A.B., Richard, E.N., 2020. Impact of used motor oil on the soil qualities of Orji Mechanic Village Owerri, Nigeria. International Journal of Engineering Technologies and Management Research. 7(2), 1-12.
DOI: https://doi.org/10.29121/ijetmr.v7.i2.2020.524

[18] Lahlou, K., Doghmi, H., Schneider, F., 2020. The Size and Development of the Shadow Economy in Morocco [Internet]. Available from: https://ideas.repec.org/p/ris/bkamdt/2020_003.html

[19] Shehu, P., Rikko, L.S., Azi, M.B., et al., 2023. Assessment of the spatial pattern, nature, and growth drivers in selected peri-urban areas. International Journal of Human Capital in Urban Management. 8(2), 195-214.
DOI: https://doi.org/10.22034/ijhcum.2023.561130.1540

[20] Annagu, F., 2020. Used Motor Oil Vendors as 'Pollution Pathogens' in the Environment [Internet]. Available from: https://www.environewsnigeria.com/used-motor-oil-vendors-as-pollution-pathogens-in-the-environment/

[21] Damina, B.G., Andrew, J.B., Yakubu, A.U., et al., 2016. Violation of development control provisions by public and semipublic developers along Kachia Road, Kaduna Metropolis. Journal of Environmental Science, Toxicology and Food Technology. 10(8), 146-151.
DOI: https://doi.org/10.9790/2402-100802146151

[22] Karimi, K., Faghri, A., 2021. The issues of roadside litter: A review paper. Current Urban Studies. 9(4), 779-803.
DOI: https://doi.org/10.4236/cus.2021.94046

[23] Nur, A.L.A., Emmanuel, K.J.O., Tarlue, J.V.P., et al., 2019. Assessment of used oil management at the filling stations within makindye division in Kampala. African Journal of Environment and Natural Science Research. 2(1), 64-72.

[24] Oloruntoba, E.O., Ogunbunmi, T.O., 2020. Impact of informal auto-mobile mechanic workshops activities on groundwater quality in Ibadan, Nigeria. Journal of Water Resource and Protection. 11(7), 590.
DOI: https://doi.org/10.4236/jwarp.2020.127036

[25] Ebije, N., 2021. Kaduna: 150 Motor Mechanics Displaced by Demolition, Obtain Forms Worth N1.5 Million for Permanent Sites [Internet]. Available from: https://sunnewsonline.com/kaduna-150-motor-mechanics-displaced-by-demolition-obtain-forms-worth-n1-5-million-for-permanent-sites/

[26] Obinia, U., Afiukwaa, J.N., 2013. Environmental and health impact of waste engine oil disposal in Nigeria: A review. Education and Science Journal of Policy Review and Curriculum Development. 3(3), 54-61.

[27] Udebuani, A.C., Okoli, C.G., Okoli, I.C., et al., 2011. Assessments of the volume and disposal methods of spent engine oil generated in Nekede mechanic village, Owerri, Nigeria. Report and Opinion. 3(2), 31-36.

[28] Michael, A., 2015. Used oil storage and disposal practices in automobile repair garages in Ghana. International Journal of Science, Technology and Society. 3(4), 191-201.
DOI: https://doi.org/10.11648/j.ijsts.20150304.23

[29] Ssempebwa, J.C., Carpenter, D.O., 2009. The generation, use and disposal of waste crankcase oil in developing countries: A case for Kampala district, Uganda. Journal of Hazardous Materials. 161(2-3), 835-841.
DOI: https://doi.org/10.1016/j.jhazmat.2008.04.028

[30] Ataro, Z., Geremew, A., Urgessa, F., 2018. Occupational health risk of working in garages: Comparative study on blood pressure and hematological parameters between garage workers and Haramaya University community, Harar, eastern Ethiopia. Risk Management and Healthcare Policy. 35-44.
DOI: https://doi.org/10.2147/RMHP.S154611

[31] Omorowa, F.E., Agu, K.C., Okolie, N.P., et al., 2015. Influence of spent-engine oil on hematology, renal

and liver status of auto-mechanics of Benin-City, Nigeria. Journal of Applied Sciences and Environmental Management. 19(3), 383-386.
DOI: https://doi.org/10.4314/jasem.v19i3.6

[32] An, N.B., Kuo, Y.L., Mabrouk, F., et al., 2023. Ecological innovation for environmental sustainability and human capital development: The role of environmental regulations and renewable energy in advanced economies. Economic research-Ekonomska istraživanja. 36(1), 243-263.
DOI: https://doi.org/10.1080/1331677X.2022.2120046

[33] Arora, N.K., 2018. Environmental sustainability—necessary for survival. Environmental Sustainability. 1(1), 1-2.
DOI: https://doi.org/10.1007/s42398-018-0013-3

[34] Hunter, N., Walsh, B., Ramos, G.C.D., et al., 2023. Cities and climate change science after Edmonton: Knowledge, people, and organisations' influence and outreach. Current Research in Environmental Sustainability. 6, 100231.
DOI: https://doi.org/10.1016/j.crsust.2023.100231

[35] Ala-Mantila, S., Kurvinen, A., Karhula, A., 2023. Measuring sustainable urban development in residential areas of the 20 biggest Finnish cities. npj Urban Sustainability. 3(1), 49.
DOI: https://doi.org/10.1038/s42949-023-00127-8

[36] Madanaguli, A., Dhir, A., Joseph, R.P., et al., 2023. Environmental sustainability practices and strategies in the rural tourism and hospitality sector: A systematic literature review and suggestions for future research. Scandinavian Journal of Hospitality and Tourism. 23(1), 1-28.
DOI: https://doi.org/10.1080/15022250.2023.2174179

[37] Akpu, B., Tanko, A., Jeb, D., et al., 2017. Geospatial analysis of urban expansion and its impact on vegetation cover in Kaduna Metropolis, Nigeria. Asian Journal of Environment & Ecology. 3(2), 1-11.
DOI: https://doi.org/10.9734/AJEE/2017/31149

[38] El-Rufai, N., 2020. Kaduna State Development Plan 2021-2025: Transforming Kaduna into a Knowledge-Based Economy [Internet]. Kaduna State Government. Available from: https://www.opengovpartnership.org/wp-content/uploads/gravity_forms/24-6fb2e5a17f4b-4b4e72048871008bb9f3/2021/10/KADUNA-SDP-2021-20251.pdf

[39] Murtala, M., 2019. Effects of Climate Change on Cowpea Yield in Kaduna State, Nigeria [Internet]. Available from: https://www.perlego.com/book/3399352/effects-of-climate-change-on-cowpea-yield-in-kaduna-state-nigeria-evidence-from-rainfall-and-temperature-parameters-pdf

[40] World Population Review, 2023. World Cities—Kaduna Population [Internet]. Available from: https://worldpopulationreview.com/world-cities/kaduna-population

[41] Road Transport Data (Q4 2018) [Internet]. National Bureau of Statistics; 2018. Available from: https://nigerianstat.gov.ng/elibrary/read/903

Appendix

Appendix I. Used engine oil vendors coordinate.

S/N	Location	Address	Latitude	Longitude
1	Maraban Rido	Chukason Enterprice Nig. Ltd, Kachia Rd, Marraban Rido.	10°26'09.98"N	7°23'12.34"E
2	Sabon Tasha	Beside Con oil, sabo- ung. Boro	10°27'01.47"N	7°27'41.74"E
3		Adj. Banns oil, Bypass way	10°26'50.04"N	7°23'49.10"E
4	Kakuri	Old Artillery, opposite Queen Amina	10°28'33.33"N	7°25'11.08"E
5	Gonin-Gora	Opp. Future oil, Abuja express way	10°26'36.61"N	7°24'27.93"E
6	Tirkania	Front of Textile labor house, Nnamdi Azikiwe Express way (Bypass way)	10°26'41.31"N	7°23'58.84"E
7		Behind NDA, Bypass way	10°34'12.81"N	7°25'04.18"E
8	Mando	Behind Mando heavy truck motor pack	10°34'51.83"N	7°25'42.80"E
9	Rigachukun	Rigachikun junction, Zaria-Kano exp. way	10°36'41.83"N	7°27'55.76"E
10		Beside Overhead bridge, Maraban Jos	10°37'10.33"N	7°28'02.71"E
11	Oriapata	Dan Musa road, Oriapata	10°30'28.97"N	7°25'28.75"E
12		Behind Wilcon enter. Nig. Dan Musa Rd	10°30'30.72"N	7°25'28.99"E
13		Behind AL-Hikham Inter. School	10°30'31.70"N	7°25'25.94"E
14	Mellinium City	Beside Mu'asma Integrated	10°31'57.29"N	7°28'58.99"E
15		Beside Sabon gida JTF, Hayin Danbushiya	10°32'03.58"N	7°28'53.83"E
16	Maigero/Karji	Yakowa road, before River Kaduna bridge	10°30'04.83"N	7°27'56.86"E

Appendix II. Abbreviations.

GIS	Geographic Information System
GPS	Global Positioning System
ITD	Intertropical Discontinuity
KadGIS	Kaduna Geographic Information Services
KASUPDA	Kaduna State Urban Planning and Development Authority
KEPA	Kaduna Environmental Protection Agency
LGA	Local Government Area
UEO	Used Engine Oil
UEOVs	Used Engine Oil Vendors
SDG	Sustainable Development Goal