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Challenges of Used Lead Acid Battery (ULAB) Waste Management in Obosi, Anambra State, Nigeria

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Abstract
The management of Used Lead-acid Batteries (ULABs) presents significant environmental and health challenges due to ULAB's constituent materials. This study investigates current ULAB management practices, identifies associated challenges, and proposes recommendations for improvement. This study highlights the importance of addressing hazardous waste due to the toxic components of ULABs, such as lead and sulfuric acid, which pose severe health and environmental risks if not properly managed. The research employed a survey design, utilizing both primary and secondary data to assess ULAB management practices, awareness, and challenges in Obosi. Findings revealed the predominance of informal ULAB waste collectors, lack of awareness about safe handling and recycling practices, and inadequate regulatory enforcement. Most ULABs are sold or exchanged informally, with minimal engagement in formal recycling. The study identified core challenges including inadequate awareness, poor enforcement of regulations, and lack of proper management facilities. Recommendations provided include public awareness campaigns, enforcement of regulations, investment in dedicated ULAB management facilities, formalizing informal recycling operations, and providing financial incentives for sustainable practices. These strategies aim to mitigate the environmental and health risks associated with ULAB waste, promoting sustainable waste management in Obosi and similar regions. Addressing these issues is crucial for enhancing ULAB management in Obosi and beyond, ensuring sustainable environmental and public health outcomes.

Keywords: *Used Lead-Acid Batteries (ULABs), waste management, ULAB management challenges, environmental pollution, health risks, Obosi.*

INTRODUCTION

Lead-acid batteries (LABs) are a crucial component of numerous devices and systems, acting as power sources for households, commerce, and industries (Zafar, 2020). The global production of LABs has surged with the increasing demand for reliable backup power supplies, driven by industrialization and urbanization. Annually, approximately 3 million tons of waste batteries are generated, and this figure is expected to rise as economies continue to develop rapidly (Zhang et al., 2016). Higher-income levels lead to increased consumption and quicker disposal of goods, further exacerbating waste generation (Uchegbu, 2009; Rajput, Prasad & Chopra, 2019). Effective waste management systems are essential for mitigating the environmental impact of this growing waste stream. In developed countries, robust facilities and competent government institutions manage waste efficiently (Rajput et al., 2019). However, developing countries like Nigeria often struggle to establish proper waste management systems. In many African nations, including Nigeria, waste is frequently dumped indiscriminately, posing significant threats to human health and the environment. Hazardous wastes, such as lead-acid battery (LAB) waste, are particularly of concern due to their toxic components, including lead and sulfuric acid, which can have severe health implications if not properly managed (Renewable Energy Association of Nigeria, 2020).

Exposure to lead can cause severe health issues, including brain and kidney damage, impaired hearing, and various other problems (Zafar, 2020). Sulfuric acid, being highly corrosive, also presents significant handling risks. Despite these hazards, used lead-acid batteries (ULABs) can be recycled sustainably at their end-of-life stage to prevent environmental and health hazards. Although the Nigerian government has ratified the Basel Convention to regulate the transboundary movement of hazardous wastes, including ULAB (Arowolo, 2010), improper management remains a significant issue, particularly in regions like Anambra State.

In Anambra State, the management of ULABs is characterized by significant challenges (Ekwegh, 2018). Informal collectors and traders dominate the ULAB market, leading to insufficient formal recycling infrastructure and poor regulatory enforcement (UNICEF and Pure Earth Organization, 2020). This situation results in considerable environmental and health risks. Poorly managed LAB waste can cause lead contamination in soil, water, and air, which poses severe health risks to humans, especially children, who are particularly vulnerable to lead poisoning (Ekwegh, 2018; Fred, 2020; Chakraborty, 2021). Research has shown that improper ULAB management can lead to significant environmental pollution. The informal recycling of ULABs, often carried out in hazardous conditions, exposes workers and nearby communities to toxic substances, leading to severe health issues (Osibanjo, 2016; Ekwegh, 2018; Paul et al., 2019). Despite these challenges, ULAB recycling presents significant economic opportunities. Recycling lead from ULABs is a profitable business worldwide (Ekwegh, 2018), and proper recycling practices can reduce environmental pollution while promoting economic growth (Islam et al., 2021). In developed countries, nearly all components of LABs are recycled, creating new batteries from old ones and significantly reducing the need for new raw materials (ILA, 2015). However, in developing countries, inadequate recycling facilities and regulatory frameworks hinder effective ULAB management (World Economic Forum, Global Battery Alliance, 2019).

In Obosi, the informal sector's dominance in ULAB recycling leads to poorly regulated processes that pose severe risks to human health and the environment. Most LAB wastes are recycled and exported informally without adequate regulations, resulting in significant environmental pollution (Ekwegh, 2018). Additionally, unlicensed battery reconditioners and illegal recyclers contribute to the problem, operating without proper oversight and using crude methods that endanger both the environment and human health (UNEP, 2017).

While various researchers like (Fred, 2020; GBA, 2020; Tian et al., 2017; Van der Kuijp et al., 2013 and UNICEF and Pure Earth, 2020) have addressed the general challenges of ULAB management in developing countries, there is a notable gap in research specifically focusing on Obosi. This research aims to fill this gap by assessing the management practices of ULABs in Obosi and identifying the associated challenges. The primary objectives are to identify current ULAB management practices, identify the challenges faced, and develop recommendations for effective ULAB waste management. Understanding these aspects is crucial for formulating strategies to improve ULAB management in Obosi and mitigate the associated environmental and health risks. By addressing the identified challenges and proposing effective ULAB waste management practices, this study intends to contribute to the development of sustainable waste management systems in Anambra State and beyond. It provides a foundation for improving ULAB management in Obosi and other similar regions. The insights gained from this research will be valuable for developing strategies to manage hazardous waste more effectively and sustainably, ensuring better environmental and public health outcomes.

MATERIALS AND METHODS

Study Area

Obosi is situated in Idemili North, the eastern part of Anambra State, South-Eastern Nigeria, on latitudes 6° 6' N and 6° 10' N and longitudes 6° 50' E and 6° 56' E (Figure 1). The town lies within the southeastern portion of the Anambra Basin, characterized by undulating terrain with moderate elevations and gently rolling hills. It is bounded in the east by Nkpor and Umuoji, in the North by Nkwelle–Ezunaka and Onitsha, in the west by Ogbaru and in the south by Ojoto (Ejikeme, *et al*, 2021). This geographical setting influences both the physical landscape and human activities in the area.

The climate of Obosi follows the tropical wet and dry pattern according to the Köppen climate classification. This climatic regime is largely governed by the movement of the intertropical discontinuity (ITD), which brings about a distinct division between the dry and wet seasons. The dry season spans from November to March, dominated by dry continental North-East winds, while the wet season extends from April to October, driven by the moist maritime South-West winds. There is usually a break in August (the August break). The mean annual rainfall in Obosi is approximately 1800mm. The area experiences mean minimum and maximum temperatures of about 24°C and 31°C, respectively. These climatic conditions support a variety of vegetation types, predominantly comprising tropical rainforest species, although human activities have significantly altered the natural vegetation cover.

Obosi is an urban area with a high population density and vibrant economic activities, particularly in trade, transportation, and small-scale manufacturing. The town is a significant hub for automobile-related businesses, including numerous repair shops and battery dealers.

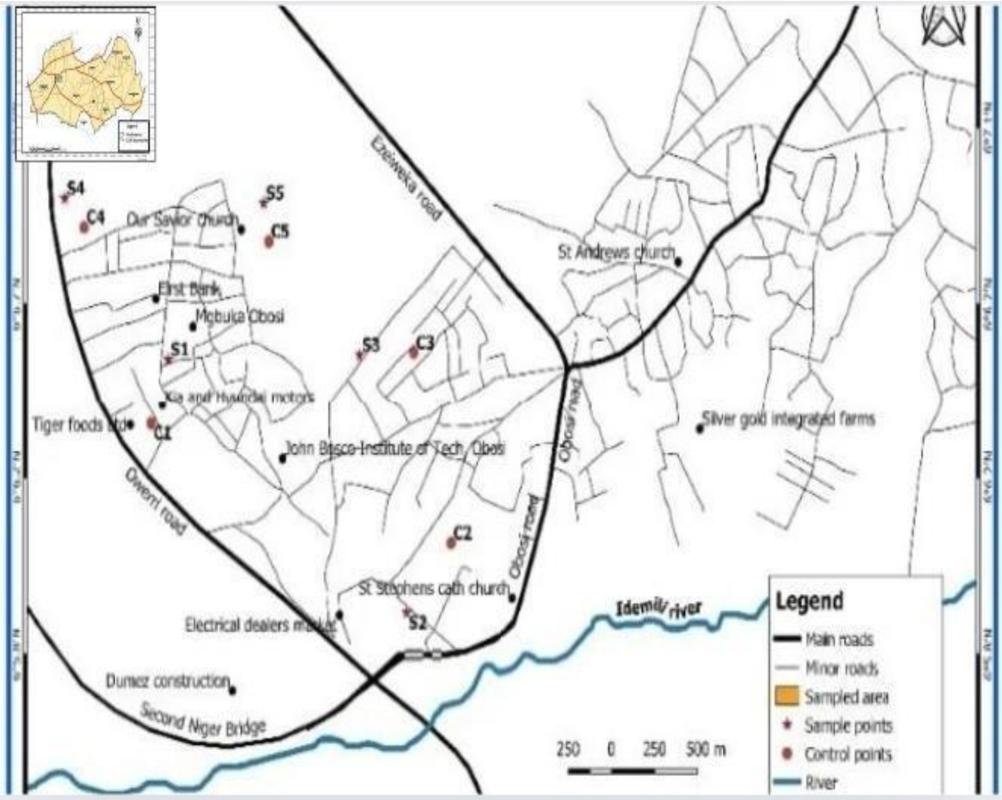

Figure 1: Map of Obosi

Data Collection

This study employed a survey research design while utilizing both primary and secondary data sources to assess the current practices and challenges of used lead-acid battery (ULAB) waste management in Obosi. Primary data were collected directly from the field within the study area through field observations and by administering structured questionnaires to respondents involved in ULAB activities and households living close to ULAB collection and management centers. Secondary data were gathered from relevant literature, including previous research, reports, and documents related to ULAB management practices. Primary data collection involved administering structured questionnaires featuring closed-ended questions and also questions in a Likert-scale format. These questionnaires gathered information on ULAB handling practices, disposal methods, awareness of environmental risks, and ULAB management challenges. Field observations were conducted to assess current practices at ULAB storage sites and disposal areas, with observations documented through field notes and photographs.

Data Analysis

This study incorporated both quantitative and qualitative techniques for data analysis. Questionnaire data were summarized descriptively using frequencies, percentages, and charts while field observations were conducted to systematically gather qualitative data on ULAB management infrastructure, practices, and environmental conditions in Obosi. This method allowed for a firsthand understanding of how ULABs were handled, stored, transported, and disposed of in the study area.

RESULTS

Data were collected from a sample size of 200 respondents in Obosi, Idemili Local Government Area (LGA). The questionnaire response rate was 87%, indicating a robust engagement from the respondents, as seen in Table 1.

Table 1: Number of questionnaires administered and returned

Study area	Sample size	Returned questionnaires	Percentage response
Obosi	200	174	87%

Demographic characteristics of the respondents

The demographic profile in Table 2, shows a predominantly male population (95.4%).

Table 2: Gender distribution

Gender	Number of Respondents	Percentage
Male	166	95.4%
Female	8	4.6%
Total	**174**	**100%**

Table 3 shows that the majority of respondents were in the age group of 35-44 years, constituting 54.6% of the sample. Indicating that the majority of the respondents were within the productive age bracket and had the expected experience to answer the questions contained in the questionnaire.

Table 3: Age group of the respondents

Age group	No. of Respondents	Percentage
18-24	3	1.7%
25-34	14	8.1%
35-44	95	54.6%
45-54	51	29.3%
55 and above	11	6.3%
Total	**174**	**100%**

Also, the occupation of the respondents was sought based on the work category defined in the questionnaire. The occupation distribution (Table 4) indicated that 6.3% of respondents were ULAB dealers, with a significant number engaged in other occupations such as commercial driving which is also a source of ULAB.

Table 4: Occupation of the respondents

Occupation	Number of Respondents	Percentage Distribution
ULAB dealer	11	6.3%
Commercial driver	39	22.4%
ULAB transporter	0	0
Others (Residents or shops close to ULAB collection centers)	124	71.3%
Total	**174**	**100%**

Management Practices for ULAB in Obosi

The study investigated the methods employed by residents of Obosi for managing and disposing of Used Lead-Acid Batteries (ULAB). Respondents were given various options to choose from, reflecting their practices and awareness regarding ULAB management.

The most common disposal method in Obosi (Table 5) was selling or exchanging ULABs with dealers for new lead-acid batteries (LAB), with 89% of respondents indicating this practice. This high percentage suggests a prevalent reliance on informal recycling networks and trade practices for ULAB disposal. Despite this, only a small fraction of respondents (2%) reported participating in formal recycling activities. This indicates a significant gap in the integration of formal recycling systems within the community. A concerning 3% of respondents admitted to disposing of ULABs with regular household waste. Given the hazardous nature of lead-acid batteries, this practice poses substantial environmental and health risks due to the potential for lead contamination. Also, 6% of respondents were unsure of the correct disposal methods or used other unspecified methods. This uncertainty underscores a lack of comprehensive knowledge and awareness regarding safe ULAB management practices.

Table 5: Disposal method of the respondents

Disposal method	No. of respondents	Percentage
Recycle	3	2%
Sell/Exchange	155	89%
Dispose with regular household wastes	6	3%
Others/Not sure	10	6%
	174	100%

Awareness and Knowledge of ULAB Recycling and Effects in Obosi

The study assessed respondents' awareness of ULAB recycling companies, their knowledge of the effects of ULAB on health and the environment, and their understanding of regulatory measures related to ULAB management, (Table 6).

The results revealed that an overwhelming majority of respondents in Obosi (74%) were unaware of any recycling companies focused on ULAB collection. Only 1 respondent (0.6%) was aware of such facilities, while 25% were unsure. This indicates a significant lack of awareness regarding the formal recycling infrastructure available for ULAB management.

Regarding the potential effects of ULAB on human health and the environment, 35% of respondents in Obosi acknowledged understanding these impacts. However, a larger proportion, 42%, lacked knowledge on this subject, and 23% were unsure. This highlights a critical knowledge gap among the population about the environmental and health risks associated with improper ULAB disposal.

Moreover, none of the respondents in Obosi were aware of any regulatory measures or instruments designed to enforce standard practices for controlling lead exposure and managing ULAB. This complete lack of awareness about existing regulations is alarming, especially given the significant trade of vehicle parts and batteries in local markets such as Mgbuka-Obosi.

Table 6: Respondent's knowledge of the availability of ULAB recycling companies, effects of ULAB and regulatory measures

Availability of ULAB recycling companies	**Yes**	**No**	**Not sure**
Number of respondents	1	129	44
Percentage	0.6%	74%	25%
Effects of ULAB on Health and Environment	**Yes**	**No**	**Not sure**
Number of respondents	61	73	40
Percentage	35%	42%	23%
Knowledge of any regulatory measures	**Yes**	**No**	**Not sure**
Number of respondents	0	94	80
Percentage	0%	54%	46%

The study further obtained information from the respondents on the storage approaches adopted for ULAB before disposal. The responses shown in Table 7 show that most of the ULABs are stored without consideration of any safety measures as shown by 63% of the responses obtained from the study area, while 30% of the responses were shown to store these ULABs with consideration of certain safety measures.

Table 7: Storage pattern adopted by the respondents

Storage Approaches	Number of Respondents	Percentage
Storage with safety measures	52	30%
Storage without any safety measures	110	63%
Others	12	7%
Total	**174**	**100%**

The study gathered more information from respondents on the extent and nature of management practices employed for taking care of Used Lead-Acid Batteries (ULAB) in Obosi. A 5-point Likert scale was used to assess these practices, focusing on how environmentally friendly and sustainable they are. Respondents rated their level of agreement with statements regarding ULAB management practices, with responses ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Table 8 presents the respondents' perceptions of ULAB management practices in Obosi. The mean values of responses for each question indicate a general disagreement with the statements about environmentally sound and regulated ULAB management practices. Specifically, the average ratings for Obosi were as follows:

1. The majority of ULABs in this area are collected in an environmentally sound manner: Mean = 2.3
2. ULABs in your area are stored safely to prevent environmental contamination: Mean = 2.1
3. ULAB transportation methods are by regulations: Mean = 2.0
4. Proper ULAB disposal methods are commonly practiced: Mean = 2.0

These ratings suggest that respondents generally disagreed with the notion that ULABs are managed in a safe and environmentally friendly manner. The low mean scores highlight significant gaps in the proper collection, storage, transportation, and disposal of ULABs in Obosi.

Table 8: Level of Agreement on Sustainable ULAB Management Practices in the Study Areas.

S/N	Items	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Average
1	The majority of ULABs in this area are collected in an environmentally sound manner	24	97	29	24	0	**2.3**
2	ULABs in your area are stored safely to prevent environmental contamination	31	99	32	12	0	**2.1**

3	ULAB transportation methods are by regulations.	22	134	16	2	0	**2.0**
4	Proper ULAB disposal methods are commonly practiced	18	133	21	2	0	**2.0**
	Average						**2.1**

The Likert scale result was further converted into percentages for each of the questions and shown in Figure 2.

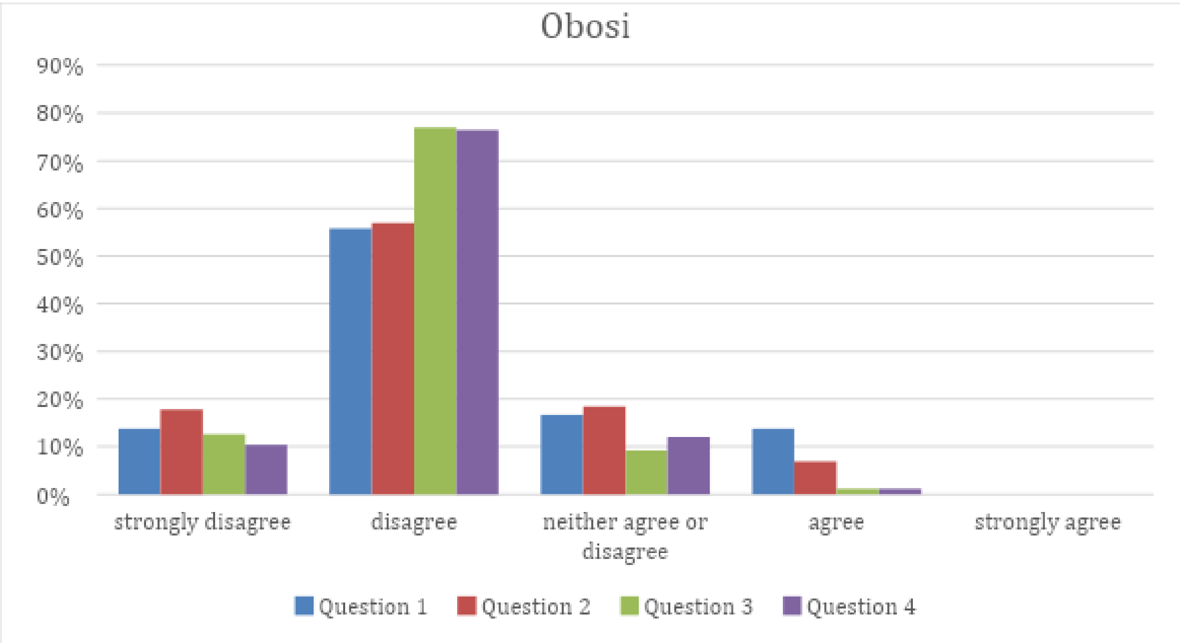

Fig 2: Level of Agreement on Sustainable ULAB Management Practice in Obosi.

The study highlighted significant challenges in the management of Used Lead-Acid Batteries (ULABs) in the study area.
The likely challenges associated with managing ULAB in the study area were limited to three core issues namely inadequate awareness, poor enforcement of regulations and lack of proper management facilities. The responses obtained are shown in Table 9.

Table 9: Perceived Challenges of Managing ULAB

Management challenges	**Number of respondents**	**Percentage**
inadequate awareness	137	78.7%
poor enforcement of regulations	134	77%
lack of proper management facilities	144	82.8%

From the responses shown in Table 9, a significant majority (78.7%) of respondents in Obosi noted inadequate awareness as a major challenge. The enforcement of regulations related to ULAB management is another critical issue, with 77% of respondents identifying it as a challenge. However, the most prevalent challenge identified by respondents is the lack of proper management facilities, with 82.8% of participants in the study area acknowledging this issue.

DISCUSSION

The management of used lead-acid batteries (ULAB) in Obosi presents significant challenges, as revealed by the survey results and field observations. The primary aim of this research was to identify current ULAB management practices, uncover the associated challenges, and propose recommendations for effective waste management. The findings from this study provide a comprehensive understanding of the situation in Obosi, aligning with and diverging from existing literature in notable ways.

The study revealed that the management of ULABs in Obosi was primarily dominated by informal collectors and traders. These individuals often lack awareness about safe handling and disposal practices, leading to hazardous conditions. Only a small fraction of respondents (2%) reported participating in formal recycling activities, highlighting a heavy reliance on informal networks. This contrasts sharply with the structured and regulated ULAB management practices observed in developed nations, where recycling systems are robust and efficient (ILA, 2015).

Three core challenges were identified in ULAB management in Obosi: inadequate awareness, poor enforcement of regulations, and lack of proper management facilities. A significant majority of respondents (78.7%) highlighted inadequate awareness as a major issue. This aligns with findings from Ekwegh (2018) and UNICEF and Pure Earth Organization (2020), who noted that informal collectors and traders dominate the ULAB market in Nigeria, often lacking awareness about safe handling and disposal practices. The lack of awareness was further evidenced by the fact that 74% of respondents were unaware of any recycling companies focused on ULAB collection, indicating a significant gap in public knowledge and outreach efforts.

Poor enforcement of regulations was identified by 77% of respondents as a critical challenge. This finding is consistent with the literature, which points to insufficient regulatory frameworks and weak enforcement as major barriers to effective ULAB management in developing countries (Rajput, Prasad & Chopra, 2019; World Economic Forum, Global Battery Alliance, 2019). In Obosi, none of the respondents were aware of any regulatory measures designed to enforce standard practices for controlling lead exposure and managing ULAB. This complete lack of awareness about existing regulations underscores the need for stronger regulatory oversight and better dissemination of information to the public.

The most significant challenge identified was the lack of proper management facilities, as noted by 82.8% of respondents. This finding agrees with Chakraborty (2021) and Fred (2020), who highlighted that inadequate infrastructure for safe storage, transportation, and recycling of ULABs is a common issue in developing countries. Field observations corroborated this, revealing that ULABs in Obosi are often stored without precautionary measures to prevent environmental contamination and transported in unsafe conditions. These practices pose significant environmental and health risks, as also noted by Ekwegh (2018) and Osibanjo (2016).

Field observations further corroborated these findings, revealing several critical issues in ULAB waste management practices in Obosi. ULABs were handled, stored, and transported in ways that posed significant environmental and health risks. Storage facilities were often inadequate, lacking proper containment measures to prevent leaks and spills (Figure 3). ULABs were frequently transported in unsafe conditions, such as open vehicles, wheelbarrows, and trucks, without effective waste treatment systems in place. Visible signs of contamination, such as spills and emissions, were common, indicating substantial environmental pollution. These observations align with previous research on ULAB exposure through management practices without adequate safety measures, leading to potential health problems such as lead poisoning (Paul et al., 2019). Airborne pollutants and leachates from ULAB sites can contaminate drinking water sources and agricultural lands, affecting the health of residents, especially vulnerable populations like children and pregnant women (UNICEF and Pure Earth, 2020).

Figure 3: Open the ULAB Storage Site

The study further revealed that the economic potential of ULAB recycling is not fully realized in Obosi. Ekwegh (2018) and Islam et al. (2021) noted that recycling lead from ULABs can be a profitable business and contribute to economic growth. However, in Obosi, the informal sector's dominance and lack of formal recycling infrastructure hinder the realization of these economic benefits. As revealed from the responses obtained from the respondents, most ULABs are sold or exchanged with dealers for new batteries (89%), indicating a prevalent reliance on informal trade practices rather than formal recycling systems.

Comparative analysis with developed regions provides valuable insights into better ULAB management practices. Developed countries have a more unified collection system and better infrastructure for managing ULABs, as noted in previous studies (ILA, 2015; Rajput et al., 2019). Reviewing best practices from these regions highlights the potential for improvement in Obosi. Successful ULAB management strategies include establishing proper collection and storage facilities, implementing safe transportation methods, and ensuring effective recycling processes.

CONCLUSION AND RECOMMENDATIONS

The management of used lead-acid batteries (ULABs) in Obosi faces significant challenges, primarily due to inadequate awareness, poor regulatory enforcement, and insufficient management facilities. These issues contribute to hazardous environmental conditions and health risks for the local population. Despite these challenges, there is potential for significant improvement in ULAB management practices in Obosi through targeted interventions. The study identified that the ULAB management in Obosi is largely informal, with inadequate awareness of safe handling and disposal practices. The lack of formal recycling infrastructure and regulatory oversight worsens the problem, leading to environmental pollution and health hazards. Additionally, the economic potential of ULAB recycling is not fully realized due to the dominance of informal trade practices.

Addressing these issues requires a multi-faceted approach. Hence, the study further provides the following recommendations for advancing sustainable ULAB management practices in Obosi and similar regions.

1. The government of Anambra State should lead public awareness campaigns to educate ULAB stakeholders of Obosi about the environmental and health risks associated with improper disposal of ULABs.
2. Anambra State Waste Management Authority (ASWAMA) should enforce strict regulations on ULAB waste management, ensuring compliance with safe handling, storage, transportation, and recycling practices.
3. Local authorities in Obosi, supported by government funding and oversight from ASWAMA, should invest in building dedicated ULAB management facilities, equipped with modern recycling technologies and secure storage infrastructure to prevent environmental contamination.
4. ASWAMA and the local government should collaborate with ULAB dealers and informal recyclers to formalize their operations, providing training and incentives to participate in regulated recycling programs.
5. Anambra State government should provide tax incentives and financial support to encourage businesses to invest in ULAB recycling infrastructure and participate in sustainable waste management practices.

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