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Full Length Research

Evaluation of the impacts of Used Lead Acid Batteries (ULAB) on the physicochemical properties of the soil in Mgbuka Obosi in Idemili North L.G.A, Anambra State

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ABSTRACT: This study examined the impacts of Used Acid-Lead Batteries on the physicochemical properties of the soil of Mgbuka Obosi in Idemili North L.G.A. of Anambra State. Six soil samples were collected for this study. Four (4) soil samples were collected from Mgbuka Obosi, while two (2) samples were collected from control sites about 2 km away from Mgbuka Obosi. The two control sites were presumed to be unaffected by ULAB-related contamination, providing a baseline for comparison. The soil samples were taken to the laboratory (Docchy Analytical Laboratories and Environment Services Limited), air dried and sieved through a 2 mm sieve for soil analysis. In the test locations, silt content ranged from 6.9 to 19.4%, while in the control locations, significantly higher silt levels were recorded (29.2% in Control 1 and 38.7% in Control 2). The pH values recorded across the test locations reveal a significant level of acidification, with Location 2 exhibiting the lowest pH value of 2.15. Comparatively, the control locations exhibited much higher pH values (5.30 in Control 1 and 6.23 in Control 2), which is indicative of more neutral soil conditions and better overall soil health. The organic matter content in the test locations ranged from 4.261% to 4.911%, slightly lower than in the control locations (5.275% and 6.312%). The hypothesis, which states that there is no significant difference between the physicochemical parameters of the soils of Mgbuka Obosi and those of the control areas, was tested using the Independent Samples t-test. From the Independent Samples Test, $t(12) = 2.365$, $p = 0.036$, with a p-value of <0.05 means that the null hypothesis of no significance difference is rejected, while the alternative hypothesis of significance difference is accepted. This implies that there is a significant difference between the physicochemical parameters of the soils of Mgbuka Obosi and the control areas, in Idemili North L.G.A. of Anambra State. From the findings, it is recommended that immediate soil remediation strategies should be implemented in the affected areas. Techniques such as phytoremediation, soil washing, or the use of chelating agents can help remove or stabilise contaminated soils. This will help restore soil fertility and reduce the risk of bioaccumulation of contamination in the food chain.

Keywords: Physical properties, physicochemical, soil, Mgbuka Obosi, used batteries.

INTRODUCTION

Growing demand for motor vehicles, fueled by economic growth and the increasing adoption of renewable energy, is directly linked to the rising requirement for lead-acid batteries. Lead-acid batteries are used extensively as a power supply source across a wide range of industries globally, powering numerous household appliances, commercial equipment, and industrial machinery. Their role is crucial in contemporary life, embracing a range of modern transportation methods such as cars, trucks, buses, boats, and trains. Lead-acid batteries serve as a means of renewable energy storage, enabling the operation of fuel, electric, and hybrid vehicles, and providing backup power in times of emergency. The recycling of Used Lead-Acid Batteries (ULAB) worldwide presents substantial environmental difficulties. Lead-acid batteries remain a popular choice due to their affordability, especially in automotive and industrial applications, even though more advanced options such as lithium-ion batteries are available. In low and middle-income countries, improper recycling practices cause significant environmental and health problems. Inadequate recycling processes release significant quantities of lead particles and fumes, polluting the air, land, and water sources. According to the United Nations Environment Programme (UNEP), global lead emissions resulting from production, usage, and recycling totalled roughly 3.6 million tonnes in 2010, with 65% emanating from waste management and recycling procedures (United Nations Environment Programme, 2020; WHO, 2017).

In Nigeria, a substantial market for used lead-acid batteries exists, valued at over N85 billion; however, much of the industry operates outside of formal regulations, resulting in significant environmental and health threats. Research conducted in the field shows that Nigeria disposes of roughly 110,300 tons of discarded lead-acid batteries every year from transportation sources, resulting in earnings of approximately N37.5 billion (Recycling and Economic Initiative Development of Nigeria) (REDDIN, 2017). However, informal recycling practices, particularly manual battery breaking, engender significant lead emissions, contributing to environmental pollution (Ekwgh, 2018). The informal sector dominates ULAB recycling in Nigeria, exacerbating environmental degradation and exposing workers and communities to high lead levels. This has led to widespread lead poisoning, particularly among children, who are most vulnerable to its toxic effects.

On average, a battery contains as much as 10 kilograms of lead, and 99 per cent of this lead is recycled for use in new batteries. Used lead-acid battery recycling is a lucrative activity carried out worldwide in both the formal and informal economies, but it also poses environmental concerns. Substantial amounts of lead particles and fumes are released into the atmosphere through improper recycling methods, contaminating soil, water sources, and other surfaces (Battery Council International, 2019; Pure Earth, 2016).

Lead-acid batteries hold crucial positions in Nigeria's automotive, telecommunications, and renewable energy industries. However, insufficient regulations and infrastructure are contributing to environmental deterioration, making it essential to conduct a thorough investigation of their environmental effects. Mgbuka Obosi, situated within the Idemili North Local Government Area of Anambra State, serves as a commercial and industrial centre, thereby presenting a suitable location for investigating the effects of informal ULAB recycling. There is an urgent necessity to investigate the physicochemical properties and levels of heavy metal contamination in the soil of Mgbuka Obosi, due to the severe environmental degradation and health hazards linked with informal ULAB recycling. This research aims to conduct a thorough evaluation of ULAB's effects on Mgbuka Obosi's soil, ultimately leading to the development of efficient mitigation methods and policy suggestions.

METHODOLOGY

The study area

Mgbuka Obosi is situated in the Idemili North Local Government Area of Anambra State in Nigeria (Figures 1 and 2). Located at approximately 6.10341°N latitude and 6.81207°E longitude (Figure 3), the town of Obosi has an elevation of about 95 meters or 312 feet above sea level (Ukah *et al*., 2025). The region encompasses low-lying plains with elevations spanning from 50 to 200 meters above sea level. This region receives between 2,500 and 4,000 mm of annual rainfall, with the greatest amounts typically falling in April and October. Typically, the average relative humidity is approximately 80%, and it rises to 90% during the wettest period of the year. The town experiences a tropical climate characterised by two distinct seasons: a wet period spanning from April to October, and a dry season lasting from November to March. The climate influences the dispersal and behaviour of pollutants. The wet season's high humidity and significant rainfall can facilitate the dispersal of pollutants, whereas the dry season's lower humidity and limited rainfall hinder the transport of contaminants.

The groundwater reservoirs present in Anambra State's soils exacerbate ecological challenges in the area. These soils, primarily coastal plain sands, are highly vulnerable to erosion and contribute significantly to ecological damage. The geologic rocks and materials beneath the unstable, poorly consolidated lateritic and acidic soils are also prone to erosion. Furthermore, the easily erodible lateritic and sandy soils are susceptible to damage by stormwater runoffs.

Methods

This study employed an experimental research approach. This method was chosen for its ability to provide objective data through measurement and analysis, which was essential for assessing environmental contamination. The study was comparative and aimed to evaluate the state of soil contamination in Mgbuka Obosi and compare it with control sites to highlight significant differences in the physicochemical properties of the soil. The data required

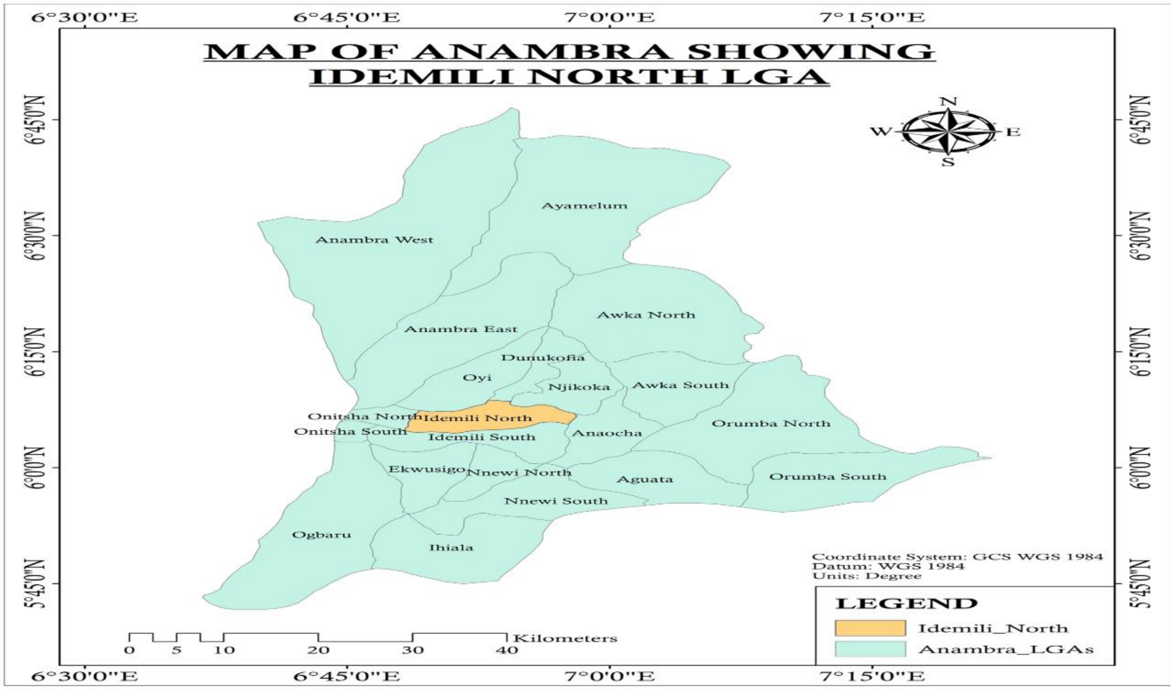

Figure 1. Map of Anambra State showing Idemili North Local Government Area.

Figure 2. Map of Idemili North LGA, Anambra State showing the location of Obosi.

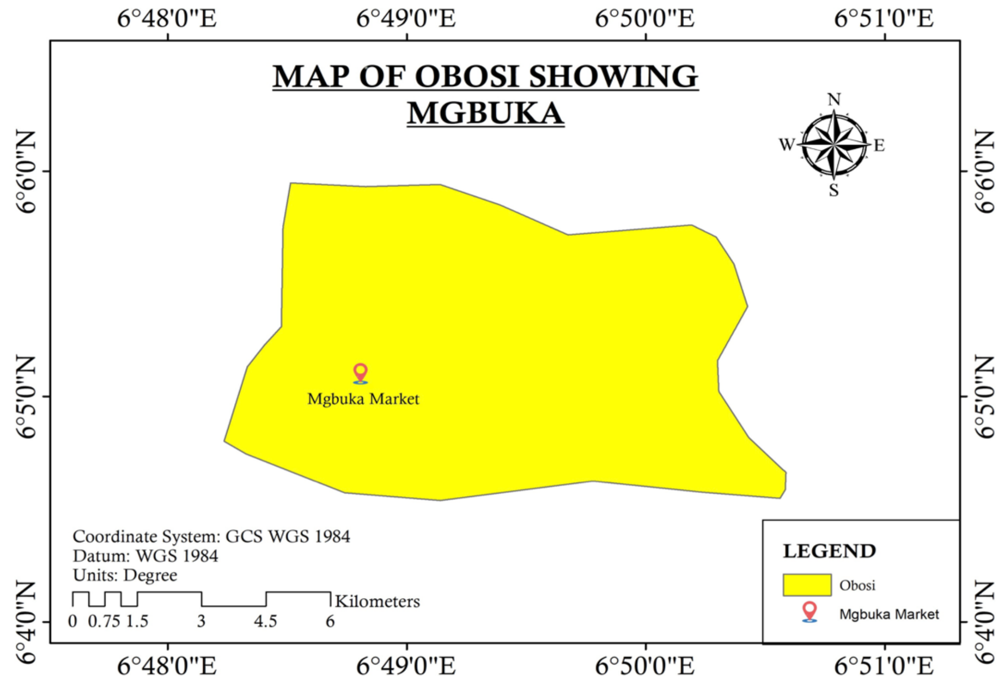

Figure 3. Map of Obosi showing the location of the study area (Mgbuka Obosi).

Table 1. Geographic coordinates of the sampling locations.

S/N	Mgbuka Obosi	Latitude	Longitude
1	Soil Sample Location 1	6°6'31"N	6°47'52"E
2	Soil Sample Location 2	6°6'37"N	6°47'49"E
3	Soil Sample Location 3	6°5'59"N	6°42'51"E
4	Soil Sample Location 4	6°5'47'N	6°45'52"E
5	Control 1	6°7'52"N	6°47'47"E
6	Control 2	6°8'01"N	6°47'39'E

for this study encompassed both primary and secondary data, which facilitated a comprehensive analysis of the environmental impact of Used Lead-Acid Battery (ULAB) in Mgbuka Obosi. The primary data included soil samples collected from various locations within Mgbuka Obosi and control sites. These samples were analysed to determine their physicochemical properties. Data obtained from the laboratory analysis of the soil samples include soil pH, soil texture, organic matter content, carbon content, and cation exchange capacity, among others.

Six (6) soil samples were collected for this study. Four (4) soil samples were collected from Mgbuka Obosi, while two (2) samples were collected from control sites about 2 km away from Mgbuka Obosi (Table 1). The two control sites were presumed to be unaffected by ULAB-related contamination, providing a baseline for comparison. A random sampling technique was employed in the course of this study. The technique was chosen for its ability to ensure representativeness and reduce bias in sampling processes. Soil samples were collected using a soil auger and GPS (for coordinates), and the samples were stored in plastic bags labelled with markers and masking tape, following standardised procedures to ensure consistency and reliability. From each sampling site, two samples (topsoil from 0cm to 15cm and subsoil from the depth of 16cm to 30cm) were collected. Both the topsoil and subsoil from each site were mixed to get a composite sample. The soil samples were taken to the laboratory (Docchy Analytical Laboratories and Environment Services Limited), air dried and sieved through a 2 mm sieve for soil analysis.

The laboratory results from the soil samples in Mgbuka Obosi and the control sites were systematically presented and analysed to draw meaningful conclusions about the

Table 2. Physicochemical parameters of soil samples.

Soil parameters	Location 1	Location 2	Location 3	Location 4	Control 1	Control 2
Silt (%)	19.400	6.900	14.300	16.500	29.200	38.700
Sand (%)	52.78	72.440	58.400	57.800	51.800	51.600
Clay (%)	27.820	20.660	27.300	25.700	19.000	19.700
pH	3.67	2.15	4.55	2.82	5.30	6.23
Organic Matter (%)	4.261	4.701	4.911	4.334	5.275	6.312
% Carbon	12.679	15.674	13.312	13.817	14.010	14.760
CEC (cmol/kg)	1.977	1.864	1.799	1.802	2.025	2.312
Soil Texture	Loamy	Sandy loamy	Sandy loamy	Sandy loamy	Loamy	Loamy

Source: Docchy Analytical Laboratories and Environment Services Limited.

environmental impact of Used Lead-Acid Battery (ULAB) on the soil parameters. The results were presented using tables. A hypothesis was stated in the course of this study. The hypothesis, which stated that there is no significant difference between the physicochemical parameters of the soils of Mgbuka Obosi and those of the control sites, was tested using the Independent Samples t-test.

RESULTS AND DISCUSSION

The impact of ULAB on the physicochemical properties of the soil in the study area

The soil analysis across the sampled locations at Mgbuka Obosi reveals significant variation in the percentages of silt, sand, and clay, indicating the impact of used lead-acid battery (ULAB) activities on the physical composition of the soil (Table 2). In the test locations, silt content ranged from 6.9% to 19.4%, while in the control locations, significantly higher silt levels were recorded (29.2% in Control 1 and 38.7% in Control 2). This reduction in silt content in the impacted areas aligns with findings by Oladejo *et al*. (2017), who observed a decrease in finer soil particles, particularly silt, in areas contaminated with heavy metals, as a result of increased weathering and erosion processes. The higher sand content in the impacted locations, particularly in Location 2 (72.44%), further corroborates this observation, suggesting that the contamination has led to the depletion of finer soil particles, thereby increasing the proportion of coarser sand.

Similarly, clay content was highest in Location 1 (27.82%), suggesting a potential accumulation of contaminants, such as lead, which tend to bind with clay particles, reducing their mobility in the soil. This finding is consistent with the studies of Otunola and Ololade (2020) and Rabiu *et al.* (2022), who also reported the preferential binding of lead to clay minerals, particularly in contaminated soils. The relatively lower clay content in the control locations (19 and 19.7%) reflects the absence of contamination and better soil structure, which is vital for maintaining soil health and fertility.

The pH values recorded across the test locations reveal a significant level of acidification, with Location 2 exhibiting the lowest pH value of 2.15. This is an indication of strong acidic conditions, which are known to increase the solubility and mobility of heavy metals like lead, making them more bioavailable and toxic to plants and microorganisms (Ubuoh *et al*., 2019). Comparatively, the control locations exhibited much higher pH values (5.30 in Control 1 and 6.23 in Control 2), which is indicative of more neutral soil conditions and better overall soil health. The acidification observed in the impacted locations is consistent with findings from previous studies that have linked ULAB activities to a drop in soil pH, as reported by Oloruntoba *et al.* (2021), where lead-contaminated soils in battery-recycling areas were found to have pH values ranging from 2.13 – 6.74, with a mean pH of 3.91 ± 1.99 thereby impairing soil fertility and increasing heavy metal toxicity.

The organic matter content in the test locations ranged from 4.261% to 4.911%, slightly lower than in the control locations (5.275% and 6.312%). This reduction in organic matter may be attributed to the contamination of the soil, which affects microbial activity and the decomposition of organic materials (Oladejo *et al.,* 2017). A decline in organic matter can also lead to reduced nutrient availability and poorer soil structure, which affects plant growth and overall ecosystem health. These findings are in line with the results of Oloruntoba *et al.* (2021), who reported that lead contamination from ULAB activities in southwestern Nigeria led to a decrease in soil organic matter and reduced soil fertility.

The percentage of carbon in the test locations followed a similar trend, with values ranging from 12.679% to 15.674%, slightly lower than the control locations (14.010% and 14.760%). This reduction in carbon content reflects a decline in the overall organic matter present in the soil. Previous studies have established that heavy metal contamination tends to inhibit the decomposition of organic materials, leading to lower organic carbon levels (Obasi et al., 2018). The relatively higher carbon content in the control soils further confirms that contamination is contributing to the degradation of soil organic matter in the

Table 3. Physicochemical parameters and WHO/FAO standards.

Soil parameters	Mean values (Mgbuka Obosi)	WHO/FAO standards
Silt (%)	14.275	40%
Sand (%)	60.355	40%
Clay (%)	25.370	20%
pH	3.298	6.0 – 8.0
Organic Matter (%)	4.552	2-5%
% Carbon	13.871	1-2%
CEC (cmol/kg)	1.861	10-30

Sources: Docchy Analytical Laboratories and Environmental Services Limited.

impacted areas.

The cation exchange capacity (CEC) values across the test locations ranged from 1.799 cmol/kg to 1.977 cmol/kg, significantly lower than in the control locations (2.025 cmol/kg and 2.312 cmol/kg). CEC is a critical indicator of soil fertility, as it measures the soil's ability to retain and supply essential cations (e.g., calcium, magnesium, potassium) to plants. The lower CEC in the impacted locations suggests that the contamination has reduced the soil's capacity to retain nutrients, likely due to the displacement of essential cations by toxic metals such as lead. These findings are consistent with the work of Oloruntoba et al. (2021), who observed similar reductions in CEC in soils contaminated by lead from battery recycling sites. The reduced CEC not only affects nutrient availability but also impairs plant growth and soil productivity in the long term.

The results of this study indicate that ULAB activities at Mgbuka Obosi have significantly degraded the soil quality in the affected areas. The acidification of the soil, reduction in organic matter, and lower CEC all point to severe soil degradation, which mirrors findings from similar studies in lead-contaminated areas across Nigeria (Ubuoh *et al*., 2019). These results underscore the urgent need for soil remediation efforts and stricter environmental regulations to mitigate the adverse effects of ULAB activities on soil health and prevent further environmental degradation.

Comparison between the physicochemical properties of the soil of Mgbuka Obosi with that of WHO/FAO standards

The comparison between the physicochemical properties of the soil from Mgbuka Obosi and the Food and Agriculture Organisation (FAO) specifications reveals significant deviations in several key parameters, indicating the environmental impact of used lead-acid batteries (ULAB) on soil quality (Table 3). Soil pH, organic matter, cation exchange capacity (CEC), and heavy metal concentrations are among the critical parameters that were compared with FAO standards for assessing soil health and safety. Starting with soil pH, the results from Mgbuka Obosi demonstrated highly acidic conditions in all tested locations, with a mean pH value of 3.298. In contrast, the FAO specifies that soil pH for healthy ecosystems and agricultural productivity should generally range between 6.0 to 8.0.

The organic matter content in Mgbuka Obosi soil shows a moderate value with a mean value of 4.552 when compared with the FAO limit. While the FAO does not specify strict guidelines for organic matter, it is widely recognised that an organic matter content of 2 - 5% or higher is ideal for maintaining soil fertility and supporting agricultural productivity.

Cation exchange capacity (CEC), which measures the soil’s ability to hold and exchange cations, is very low (1.861 cmol/kg) in the disturbed soil (Mgbuka Obosi) when compared with the FAO limit of 10 - 30 cmol/kg. The FAO generally suggests that a CEC value above 10 cmol/kg is optimal for maintaining soil fertility, particularly in agricultural soils. The low CEC value observed in the study area suggests that the soil in Mgbuka Obosi has a diminished capacity to retain essential nutrients, further exacerbating the negative impact of ULAB contamination. This decline in cation exchange capacity (CEC) could result from both the acidic conditions, which leach away nutrients, and the presence of heavy metals, which displace essential cations like calcium and magnesium from soil exchange sites.

Test of hypothesis

The hypothesis, which states that there is no significant difference between the physicochemical parameters of the soils of Mgbuka Obosi and those of the control areas, was tested using the Independent Samples t-test. From Table 4, the mean value for the physicochemical parameters of the soils of Mgbuka Obosi is 113.517 with a standard deviation of 76.474, while the mean value for the control is 38.032 with a standard deviation of 36.029. From the Independent Samples Test, $t(12) = 2.365$, $p = 0.036$, with a p-value of <0.05 means that the null hypothesis of no significance difference is rejected while the alternative hypothesis of significance difference is accepted. This

Table 4a. Test analysis results of the physicochemical parameters of the soil.

Group Statistics	Locations	N	Mean	Std. Deviation	Std. Error Mean
Physicochemical Parameters	Mgbuka Obosi	7	113.5171	76.47412	28.90450
	Control	7	38.0320	36.02858	13.61752

Table 4b. Test analysis results of the physicochemical parameters of the soil.

Independent Samples Test		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean difference	Std error difference	95% confidence interval of the difference	
									Lower	Upper
Physicochemical Parameters	Equal variances assumed	4.562	.054	2.362	12	0.036	75.48514	31.95164	5.86851	145.10178
	Equal variances not assumed			02.362	8.538	0.044	75.48514	31.95164	2.60548	148.36481

implies that there is a significant difference between the physicochemical parameters of the soils of Mgbuka Obosi and the control areas, in Idemili North L.G.A. of Anambra State.

Conclusion

This study evaluated the impacts of Used Lead Acid Batteries (ULAB) on the physicochemical parameters of the soil of Mgbuka Obosi in Idemili North L.G.A. of Anambra State. The soil analysis across the sampled locations at Mgbuka Obosi reveals significant variation in the percentages of silt, sand, and clay, indicating the impact of used lead-acid battery (ULAB) activities on the physical composition of the soil. The pH values recorded across the test locations reveal a significant level of acidification, with Location 2 exhibiting the lowest pH value of 2.15. From the results, it can be deduced that the activities (disposal and recycling of ULAB) at Mgbuka Obosi, Idemili North L. G. A. of Anambra State have a great significant effect on the soil of the study area.

Recommendations

Based on the findings of this study, the following recommendations were proposed to mitigate the impact of used lead-acid batteries (ULAB) contamination in Mgbuka Obosi and prevent further environmental degradation.

1. Immediate soil remediation strategies should be implemented in the affected areas. Techniques such as phytoremediation, soil washing, or the use of chelating agents can help remove or stabilise contaminated soils. This will help restore soil fertility and reduce the risk of bioaccumulation of contamination in the food chain.
2. There is a need for stricter enforcement of environmental regulations regarding ULAB disposal and recycling. Regulatory agencies should ensure that ULAB waste is handled and disposed of properly, following internationally accepted environmental standards. Establishing proper recycling facilities will also minimise the environmental impact.

REFERENCES

Battery Council International (2019). National Recycling Rate Study. Retrieved from https://batterycouncil.org/page/NationalRecycleRateStudy

Ekwgh, E. (2018). *Africa's challenge with Used Lead Acid Batteries (ULAB) – Can Nigeria take the lead?* Heinrich Boll Stiftung. Retrieved from https://ng.boell.org/en/2018/05/23/africa%E2%80%99s-challenge-used-lead-acid-batteries-ulab-%E2%80%93-can-nigeria-take-lead.

Obasi, S. E., Obasi, N. A., Dike, U. A., & Igbolekwu, R. I. (2016). Assessment of Physicochemical Properties and Heavy Metals Contents in Selected Dumpsites in Afikpo, Afikpo North, Ebonyi State, Nigeria. *IRA-International Journal of Applied Sciences*, *4*(3), 519-529.

Oladejo, N. A., Anegbe, B., & Adeniyi, O. (2017). Accumulation of heavy metals in soil and maize plant (Zea Mays) in the vicinity of two government approved dumpsites in Benin City, Nigeria. *Asian Journal of Chemical Sciences, 3*(3), 1-9.

Oloruntoba, E., Gurusa, O., Omokhodion, F., Fobil, J., Basu, N., Arko-Mensah, J., & Robin, T. (2021). Spatial distribution of heavy metals and pollution of environmental media around a used lead-acid battery recycling center in Ibadan, Nigeria. *Journal of Health and Pollution*, *11*(29), 210304.

Otunola, B. O., & Ololade, O. O. (2020). A review on the application of clay minerals as heavy metal adsorbents for remediation purposes. *Environmental Technology & Innovation*, *18*, 100692.

Pure Earth (2016). Fact sheet: Lead-acid battery recycling and lead pollution. Pure Earth. Retrieved from https://www.worstpolluted.org/fact-sheet-2011-lead-acid-battery-recycling-and-lead-pollution.html.

Rabiu, A. K., Ambursa, M. M., Yahaya, Y., Maiahu, F. U., & Atiku, F. A. (2022). Adsorptive behaviour of a Nigerian natural clay for the removal of lead and cadmium from aqueous solutions. *Science Journal of Chemistry*, *10*(4), 93-102.

Recycling and Economic Initiative Development of Nigeria (REDDIN) (2017). National report on used lead-acid battery management and economic valuation. Abuja, Nigeria: Federal Ministry of Environment.

Ubuoh, E. A., Umezuruike, S. O., Nworuh, B. O., & Emeka, C. C. (2019). Assessment of soil pH and heavy metal concentrations in agricultural land impacted with medical waste incinerator (MWI) flue ash (FA) in Abia State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *23*(2), 275-282.

Ukah, C., Ezenwamma, U. E., Makwe, E., & Mephors, J. O. (2025). An In-Depth Analysis of the Impact of Used Lead Acid Batteries (ULAB) on the Heavy Metal Parameters of The Soil of Mgbuka Obosi in Idemili North LGA, Anambra State. *British Journal of Environmental Sciences*, *13*(2), 32-45.

United Nations Environment Programme (UNEP) (2020). A practical guide for the remediation of used lead-acid battery recycling sites. United Nations. Retrieved from https://wedocs.unep.org/20.500.11822/32295.

World Health Organisation (WHO) (2017). Recycling used lead-acid batteries: Brief information for the health sector. Retrieved from https://www.who.int/publications/i/item/WHO-FWC-PHE-EPE-17.02.