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An Evaluation of Environmental and Waste Management Practices in Major Mechanic Clusters across Abuja, FCT Nigeria

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Abstract: This study critically examines the environmental and waste management practices in five prominent mechanic clusters across Abuja, Apo, Gudu, Karmo, Jahi, and Mabushi. These clusters, which serve as hubs for informal automobile repair and maintenance, are significant sources of environmental degradation due to poor waste handling and unregulated disposal methods. The research assesses the extent of pollution from activities such as the indiscriminate dumping of used engine oil, open burning of vehicle parts, and accumulation of scrap materials. Through field surveys, stakeholder interviews, and environmental observations, the study reveals systemic deficiencies in pollution control, infrastructure, regulatory enforcement, and public awareness. It highlights the absence of structured waste segregation, containment systems, and engagement with environmental authorities across most workshops. Despite some informal recycling practices, sustainability efforts remain fragmented and largely ineffective. The study concludes with actionable recommendations for multi-stakeholder engagement involving government, private sector, NGOs, and local mechanic associations to formalize waste management, strengthen enforcement, and promote eco-friendly practices. The findings underscore the urgent need for integrated environmental planning in Abuja's informal sectors to mitigate pollution, protect public health, and support sustainable urban development.

Keywords: *Waste Management, Pollution Control, Mechanic Clusters, Environmental Sustainability.*

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I. INTRODUCTION

Abuja, the Federal Capital Territory (FCT) of Nigeria, has been undergoing rapid urbanization, making it one of the fastest-growing cities in Africa. As the nation's capital, it serves as the political, economic, and administrative heart of Nigeria. Over the past few decades, Abuja has experienced an explosion in population, with estimates suggesting that it now hosts over 5 million residents, a figure expected to reach nearly 5.8 million by 2026 (World Population Review, 2023).

With this expansion, the demand for transportation services has surged, leading to the proliferation of automobile-related businesses, particularly mechanic workshops. These workshops have become a ubiquitous feature of urban life in Abuja, providing essential services such as car repairs and maintenance. However, the rapid growth of these informal mechanic clusters has led to growing environmental concerns, particularly regarding waste management and pollution control.

Mechanic clusters in Abuja, such as those located in Apo, Gudu, Karmo, Jahi, and Mabushi, represent the informal sector's contribution to the local economy. In these areas, mechanic workshops often operate without adequate waste management infrastructure, which exacerbates environmental pollution. Waste such as used engine oils, tires, plastic parts, batteries, and metal scrap is commonly disposed of through

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informal and unsustainable methods like open dumping, burning, or direct discharge into water bodies. These practices not only contribute to soil and water contamination but also pose significant health risks to the local population due to the toxic substances released into the environment.

The environmental impact of these informal waste management practices cannot be overstated. For example, improper disposal of used engine oil can lead to soil contamination, which, in turn, affects agricultural productivity and groundwater quality. A study by Ajayi et al. (2021) highlighted the elevated levels of heavy metals like lead (Pb), copper (Cu), and manganese (Mn) found in the soil around mechanic workshops in various Nigerian cities, indicating a clear risk to both public health and the environment. These pollutants, often leached into groundwater or washed into nearby rivers, contribute to the degradation of the natural environment, affecting the quality of life for nearby residents.

The informal nature of these mechanic clusters makes it difficult to enforce formal waste management policies. Many of these workshops are small-scale operations that lack the financial capacity to invest in proper waste disposal technologies or pollution control measures. Additionally, there is a lack of awareness regarding the long-term environmental and health consequences of improper waste disposal, which exacerbates the problem. Consequently, the sustainability of these mechanic clusters is severely compromised by the lack of proper waste management practices.

This study aims to evaluate the environmental and waste management practices within mechanic clusters across Abuja, focusing specifically on Apo, Gudu, Karmo, Jahi, and Mabushi. The primary objectives of this research are to assess the effectiveness of current waste disposal and pollution control measures, identify sustainability gaps, and propose potential solutions to improve waste management practices in these areas. The research will focus on understanding the types of waste generated, current disposal practices, the extent of pollution, and how these practices affect both the local community and the environment.

By focusing on these five mechanic clusters, the study seeks to provide an in-depth analysis of the environmental challenges posed by the informal sector and suggest practical, sustainable solutions that can be adopted by local government authorities, businesses, and the community. Understanding the waste management challenges faced by these areas is critical to developing effective policies and strategies to mitigate environmental pollution, promote public health, and ensure the sustainability of these vital economic activities.

II. LITERATURE REVIEW

The informal sector, especially in developing urban areas, often faces significant challenges in implementing proper waste management and pollution control measures. Informal sectors, including mechanic workshops, represent a large portion of the workforce in many African cities, but they typically operate outside formal regulatory frameworks. These sectors often lack the necessary infrastructure, resources, and knowledge to adopt sustainable environmental practices, leading to improper waste disposal and pollution. In the automotive repair industry, waste is generated in various forms, including used oils, solvents, vehicle parts (e.g., tires, batteries, metal scrap), and hazardous chemicals. In many developing countries, such as Nigeria, these materials are often discarded through informal methods such as open dumping, uncontrolled burning, or direct discharge into water sources. Such practices not only harm the environment but also pose significant health risks to both workers and nearby residents. For example, used engine oil, which contains hydrocarbons and heavy metals, can contaminate soil and groundwater, leading to long-term ecological damage.

Studies have shown that mechanic villages can be hotspots for oil pollution, tire waste, and chemical contamination, all of which significantly affect local ecosystems and human health. In South Asia, the lack of waste management infrastructure in informal workshops exacerbated environmental degradation, as highlighted by Chakraborty and Hossain (2019). Similarly, in Nigeria, research by Rasheed et al. (2020) pointed out that mechanic workshops are often sources of significant environmental pollutants like oil, chemicals, and metals, which affect soil, water, and air quality. In addition to the absence of waste management infrastructure, there is a widespread lack of awareness regarding the environmental impacts of improper waste disposal. Many workshops lack training on how to manage hazardous materials and chemicals safely, further aggravating the situation.

In response to the growing environmental challenges posed by informal sectors, the Nigerian government has put in place several regulations to control waste and pollution. The Federal Ministry of Environment (FMEnv) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) are the primary regulatory bodies responsible for enforcing environmental laws in Nigeria. NESREA, established in 2007, plays a pivotal role in enforcing environmental standards across sectors, including the automotive repair industry. NESREA's mandate includes regulating and enforcing compliance with environmental laws, promoting environmental education, and conducting environmental audits. The agency has developed several guidelines aimed at controlling pollution, such as the National Environmental (Hazardous Waste Control) Regulations (2003), which mandates proper disposal and treatment of

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hazardous waste, including those generated by mechanic workshops. The National Policy on the Environment (2016) also provides a framework for managing environmental pollution in all sectors, with specific guidelines on waste management. The policy emphasizes sustainable waste management practices, including waste minimization, recycling, and proper disposal. However, despite these regulations, the enforcement of environmental standards remains weak, particularly in informal sectors such as mechanic workshops, where compliance is minimal due to a lack of oversight and the informal nature of operations. The fragmented nature of the informal sector, coupled with limited resources allocated to environmental law enforcement, has resulted in inadequate implementation of these policies.

Several studies have focused on the environmental impacts of mechanic workshops and the challenges related to waste management in Nigeria. A significant body of literature documents the widespread pollution from mechanic villages, particularly in major urban areas like Lagos, Kano, and Abuja. The types of pollution associated with mechanic workshops primarily include oil, chemical waste, and metal contaminants. Used engine oil, often improperly disposed of, is a major pollutant in mechanic clusters. Research by Nwachukwu and Uzoma (2020) found that used oils are typically discarded on the ground or mixed with other waste, leading to soil and water contamination. In addition to oil, chemicals such as cleaning agents and solvents, which are used in vehicle repairs, contribute to water and air pollution. Furthermore, the improper disposal of scrap metal and car batteries leads to the release of heavy metals like lead, cadmium, and zinc, which have adverse effects on both soil and water quality.

Studies have shown that mechanic villages often have high levels of pollution in nearby water bodies and soil. Ibrahim et al. (2018) conducted research in mechanic villages in Lagos and found elevated levels of heavy metals in the soil surrounding workshops. This finding was consistent with studies by Akinmoladun et al. (2020), which reported soil contamination due to improper disposal of used oils and metal waste. In addition to soil contamination, water sources near these mechanic clusters, including rivers and boreholes, often show elevated concentrations of hydrocarbons and heavy metals, significantly affecting local drinking water quality. The impact of mechanic workshops on air quality is also notable. Exhaust fumes, solvents, and burning of waste materials release hazardous gases into the atmosphere, contributing to poor air quality. Rasheed et al. (2020) found that mechanic workshops in Nigerian cities emit pollutants like volatile organic compounds (VOCs), which can lead to respiratory issues among workers and residents.

The environmental pollution resulting from mechanic workshops has direct health implications for both workers and the surrounding communities. Ajayi et al. (2021) found that exposure to oil-contaminated soil and water increases the risk of diseases such as cancer, skin disorders, and respiratory conditions. Additionally, the contamination of water sources leads to diseases like cholera and dysentery, especially in informal settlements where access to clean water and sanitation is limited. Some studies have proposed strategies to improve waste management in mechanic villages. For example, Akinmoladun et al. (2020) recommended the introduction of waste segregation systems in mechanic workshops to separate hazardous from non-hazardous materials. Recycling of waste oils and the proper disposal of scrap metal were also highlighted as key strategies for mitigating pollution. Moreover, Nwachukwu and Uzoma (2020) proposed community-based waste management models, where mechanic workshops collaborate with local authorities to establish waste disposal systems and waste-to-energy initiatives.

The literature highlights the significant environmental and health risks posed by improper waste management practices in mechanic workshops across Nigeria. These workshops contribute to pollution through the improper disposal of oil, chemicals, and metal waste, leading to soil, water, and air contamination. Although the Nigerian government has established regulations to control pollution and waste, the enforcement of these laws in informal sectors remains a challenge. Previous studies have proposed various solutions, including waste segregation, recycling, and community-based waste management models, but more concerted efforts are needed to address the sustainability gaps in waste management practices within mechanic clusters.

III. THE STUDY AREA

This study is centered around five major mechanic clusters within Abuja, Nigeria's Federal Capital Territory (FCT): Apo, Gudu, Karmo, Jahi, and Mabushi. These clusters represent spatially distributed concentrations of informal and semi-formal automotive repair activities that significantly contribute to the local economy, while simultaneously presenting complex environmental challenges due to poor waste management practices.

- **Apo (Latitude: 9.0025° N, Longitude: 7.4833° E):** Located in the southeastern part of Abuja Municipal Area Council (AMAC), Apo is one of the most developed and densely populated areas within the FCT. The Apo mechanic village sits adjacent to several residential estates and commercial centers. It is one of the oldest and largest clusters of mechanic activities in the city. The workshops here range from small roadside setups to medium-sized garages offering auto-electrical, mechanical, and bodywork services. Due to the high vehicle throughput and large-scale operations, the area faces severe challenges from indiscriminate disposal of used oils, scrap metals, batteries, and tires, with little to no centralized waste collection or treatment systems.

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- **Gudu (Latitude: 9.0292° N, Longitude: 7.4678° E):** Gudu lies in central Abuja, strategically positioned near the Gudu District Market and adjoining residential neighborhoods. It hosts a moderately sized mechanic cluster with predominantly open-air workshops. Informality is high, with artisans operating without permanent structures or environmental safeguards. Oil spills, leaking solvents, and heaps of metal and plastic waste characterize the cluster. The geography is largely flat with limited drainage infrastructure, increasing the risk of surface runoff pollution into nearby water bodies during rainfall.

- **Karmo (Latitude: 9.0894° N, Longitude: 7.4048° E):** Positioned in the north-eastern fringe of the city, Karmo is a peri-urban district within AMAC that has experienced rapid expansion in recent years. The mechanic operations here are extensive and serve a mixed clientele, including heavy-duty trucks and public transportation fleets. Due to its proximity to Karmo market and a growing population, there is mounting pressure on the environment. The terrain here is slightly undulating, and the proximity to natural drainage channels increases the risk of pollution migration, especially from used lubricants, metal shavings, and battery acid residues.

- **Jahi (Latitude: 9.0923° N, Longitude: 7.4446° E):** Jahi is a rapidly urbanizing district in northern Abuja, bordered by high-income residential developments and major arterial roads. The mechanic activities in Jahi are less structured, often operating in open fields or temporarily occupied plots. The informal nature of operations means that there are very few, if any, containment measures for waste disposal. Waste oils are commonly dumped on the ground, and there is little separation of recyclable and hazardous materials. The soil texture in Jahi is predominantly loamy-sandy, making it highly permeable and increasing the risk of groundwater contamination.

- **Mabushi (Latitude: 9.0625° N, Longitude: 7.4483° E):** Mabushi is centrally located within Abuja and benefits from its proximity to major highways such as the Nnamdi Azikiwe Expressway. It hosts both formal and informal vehicle repair workshops. Mabushi's mechanic village is known for its concentration of high-traffic repair shops handling mechanical, electrical, and diagnostic services. While a few formal businesses adhere to basic environmental practices, the vast majority of the operators engage in open dumping and rudimentary waste disposal. The land use in Mabushi is mixed commercial, residential, and industrial making environmental pollution in this area especially concerning due to potential public health exposure.

IV. METHODOLOGY

The study covered five major mechanic hubs Apo, Gudu, Karmo, Jahi, and Mabushi selected for their spatial diversity and intensity of automotive activities.

- *Data Collection:*

Primary data collection began with structured surveys administered to a representative sample of auto-mechanics, apprentices, and workshop managers across the five clusters. The survey captured detailed information on the types of mechanical services offered, waste generation patterns (e.g., spent oil, filters, batteries, plastics, metals), handling and disposal methods, awareness of environmental regulations, and existing waste management challenges.

To complement the surveys, semi-structured interviews were conducted with key informants, including workshop owners, representatives of mechanic associations, local environmental officers, and informal waste handlers. These interviews provided contextual insights into local perceptions, informal waste flows, socio-economic drivers of unsustainable practices, and interactions (or lack thereof) with regulatory institutions.

Waste audits were also carried out to quantify the types and volumes of waste generated within each cluster. This involved direct observation and measurement of waste accumulation points, storage practices, frequency of removal, and destination of wastes (e.g., open dumping, burning, resale to scrap dealers). The audit provided evidence of material composition and potential environmental hazards.

To assess environmental impacts, environmental samples were collected from selected sites within each cluster. Soil samples were taken from locations with visible oil spills or waste dumps to assess hydrocarbon and heavy metal contamination. Water samples (especially from nearby surface drains and shallow wells) were analyzed for signs of leachate pollution, including elevated levels of Total Petroleum Hydrocarbons (TPH), nitrates, and heavy metals such as lead and cadmium. In areas with visible combustion activities, air quality measurements were carried out using portable gas analyzers to monitor pollutants such as particulate matter (PM2.5 and PM10), volatile organic compounds (VOCs), and carbon monoxide (CO).

- *Data Analysis:*

The quantitative data from surveys were analyzed using descriptive statistics to determine patterns in waste generation and disposal across the five sites. SPSS and Microsoft Excel were used to calculate frequency distributions, means, and percentages. The qualitative data from interviews and field observations were thematically analyzed to uncover recurring

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narratives and contextual drivers of environmental behavior in each cluster.

Environmental sample results were compared against national and international standards, including the National Environmental (Soil Quality) Regulations, 2020; National Environmental (Effluent Limitations) Regulations, 2011; and NESREA Guidelines for air quality. Laboratory data were also benchmarked against World Health Organization (WHO) thresholds for human and environmental safety.

V. RESULTS AND DISCUSSION

The findings from this study across the five major mechanic clusters in Abuja Apo, Gudu, Karmo, Jahi, and Mabushi reveal a pattern of widespread informal waste management practices, minimal pollution control measures, and significant environmental degradation. The analysis provides insight into how mechanics handle waste, the nature of pollution in these areas, and the underlying sustainability gaps that persist in these automotive repair zones.

A. Waste Management Practices

Waste management in the studied clusters is predominantly informal and unregulated.

Table 1: Used Engine Oil Disposal Methods by Area

Cluster	Dumped on Soil/Open Drain (%)	Stored in Containers (%)	Reused/Resold (%)
Apo	70	15	15
Gudu	60	25	15
Karmo	65	20	15
Jahi	68	22	10
Mabushi	63	18	19

Table 1 reveals that dumping used engine oil on soil or into open drains is the dominant disposal method, particularly in Apo (70%) and Jahi (68%), which indicates a persistent disregard for environmental consequences in these areas. These activities contaminate the soil and eventually seep into water bodies, posing serious ecological and public health risks. Gudu exhibited a slightly better practice, with 25% of oil stored in containers, likely due to informal awareness among mechanics or limited interventions by environmental task forces.

The reused/resold category, though relatively low (ranging from 10–19%), shows a degree of informal recycling in Mabushi and Apo, where some mechanics sell or reuse the oil for less-sensitive lubrication purposes. However, this practice remains unregulated, and there is no evidence of oil filtration or standardized reuse protocols.

Table 2: Discarded Tire Management by Area

Cluster	Burned Openly (%)	Stockpiled (%)	Sold/Recycled (%)
Apo	40	40	20
Gudu	50	35	15
Karmo	45	35	20
Jahi	48	37	15
Mabushi	42	38	20

The management of discarded tires is equally problematic. The practice of open burning is most prevalent in Gudu (50%) and Jahi (48%) (Table 2), which is deeply concerning due to the release of harmful pollutants such as benzene, styrene, and polycyclic aromatic hydrocarbons (PAHs). While Apo shows a more balanced trend with 40% burning and 40% stockpiling, these practices still pose fire and pest hazards when accumulated for long periods.

The recycling or resale of tires remains low (15–20%) in Table 2, even in areas like Karmo and Mabushi. This suggests that while there is an informal scrap network in place, its capacity is insufficient to manage the volume of tire waste produced in these clusters.

Table 3: Plastic Waste Management by Area

Cluster	Open Dumping/Burning (%)	Collected by Scavengers (%)	Stored for Disposal (%)
Apo	65	20	15
Gudu	60	30	10
Karmo	58	25	17
Jahi	63	22	15
Mabushi	55	30	15

Plastic waste, including vehicle interior panels, bumpers, and containers, is mostly burned or dumped openly, especially in Apo (65%) and Jahi (63%) Table 3. This method contributes significantly to air pollution and local respiratory illnesses, as burning plastics release dioxins and furans, both known carcinogens.

Gudu and Mabushi performed slightly better with 30% of plastic waste collected by scavengers, indicating some level of informal recovery systems. However, these systems are uncoordinated and lack environmental oversight, which limits their long-term sustainability.

There is minimal storage for proper disposal (10–17%) as shown in table 3, reflecting the absence of waste bins or municipal waste collection systems in these zones. This finding underlines the critical need for integrated waste management plans that include infrastructure and training for proper segregation and disposal of plastic waste.

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Table 4: Used Battery Handling by Area

Cluster	Sold to Scrap Dealers (%)	Abandoned on Site (%)	Stored Unsafely (%)
Apo	60	25	15
Gudu	50	35	15
Karmo	52	30	18
Jahi	55	32	13
Mabushi	58	28	14

Battery waste management shows a slightly more encouraging trend, with over 50% of used batteries sold to scrap dealers in all areas, particularly in Apo (60%) and Mabushi (58%) as shown in table 4. This is driven by the market value of lead and acid components. However, the handling and transportation of these batteries are often done without protective gear or containment, risking acid spills and lead exposure.

Abandonment of batteries on-site is still widespread in Gudu (35%) and Jahi (32%) Table 4, contributing to soil and groundwater pollution. Unsafe storage practices were common across the clusters (13–18%), suggesting that even when mechanics intend to dispose of batteries responsibly, they often lack the knowledge or means to do so properly.

The overall analysis shows that waste management across the five clusters is dominated by unsafe, informal practices. Apo and Jahi, while active centers of auto-repair, are also hotspots for pollution, with high rates of oil dumping and plastic burning. Gudu and Mabushi show slightly better handling in some waste streams, particularly with scrap collection, yet lack systemic support to fully transition into environmentally sound practices.

B. Pollution Control Measures

The findings on pollution control measures across the five major mechanic clusters in Abuja Apo, Gudu, Karmo, Jahi, and Mabushi reveal widespread deficiencies and a critical gap in environmental compliance and infrastructure. The analysis, as depicted in the chart above, illustrates the overwhelming reliance on makeshift and unsafe practices in handling hazardous materials.

Only about 10% of workshops (figure 1), mainly located in Mabushi, had designated storage areas for hazardous waste like used oil or batteries. These were typically more organized or formal garages that operated with minimal awareness of environmental guidelines. In contrast, the vast majority of 65% that resorted to using makeshift containers such as used plastic drums or improvised containers. These were often prone to leaks, vandalism, or outright spillage, creating chronic risks to soil and groundwater quality.

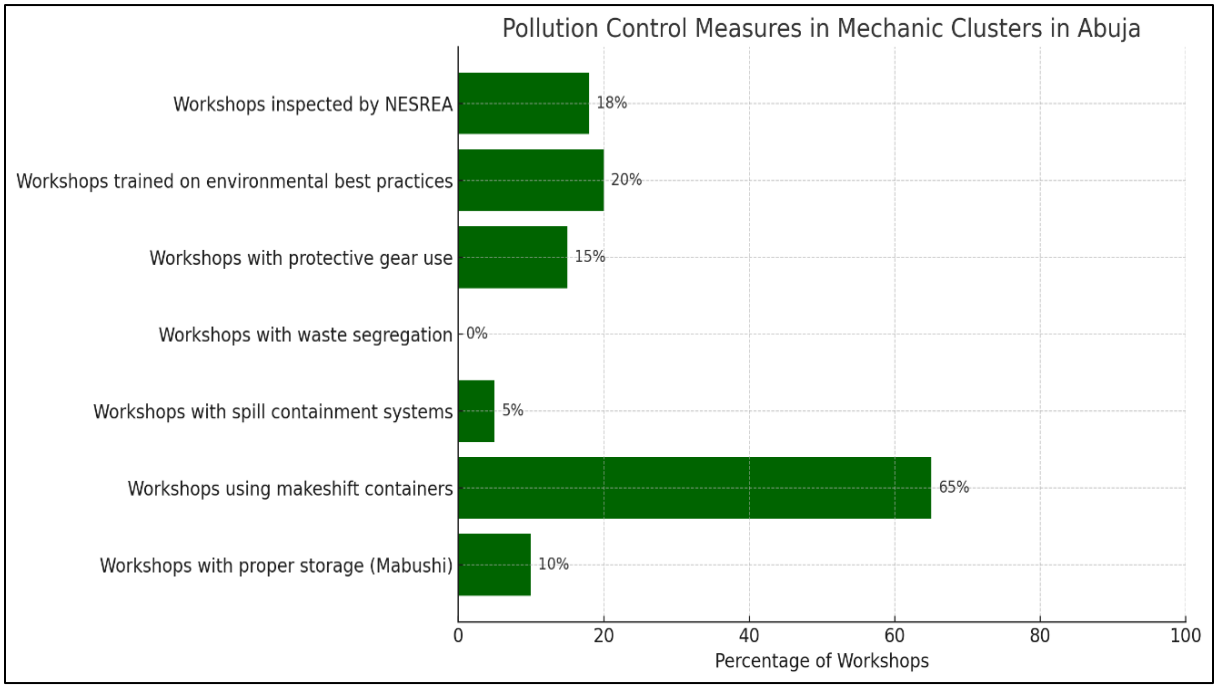

Fig 1: Pollution Control Measures in Mechanic Clusters in Abuja
Source: Field Survey, 2025

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The absence of proper spill containment systems with only 5% (figure 1) of all surveyed sites using any form of containment like bunded floors or oil traps underscores a dangerous neglect of basic pollution control. Where such systems existed, they were rudimentary and often failed due to poor design or lack of maintenance. This trend was consistent across all clusters, including larger sites in Apo and Karmo.

Even more concerning is the complete absence of waste segregation. None of the workshops surveyed had a functioning waste segregation system in place, despite the diversity of waste types generated ranging from oily rags and used filters to batteries, brake fluids, and plastics. Hazardous and non-hazardous wastes were typically mixed and dumped together, which increases the toxicity and long-term environmental risk of disposal practices.

Furthermore, only 15% (figure 1) of workshops reported using any form of protective gear when handling hazardous substances, reflecting a high level of occupational health risk for mechanics and apprentices alike. These practices not only endanger the environment but also expose workers to harmful substances such as heavy metals, hydrocarbons, and corrosive chemicals without adequate protection.

A striking insight from survey responses is that over 80% of respondents had never received environmental training or guidance on best practices for pollution control. Additionally, only 18% reported any inspection or compliance check by regulatory bodies such as the National Environmental Standards and Regulations Enforcement Agency (NESREA). This lack of enforcement further entrenches the informal nature of the clusters and their evasion of environmental oversight.

Overall, the data paints a stark picture of environmental vulnerability in Abuja's mechanic clusters. The near-absence of formal pollution control mechanisms, limited regulatory engagement, and poor awareness among operators contribute to cumulative pollution risks. These findings emphasize the urgent need for targeted interventions such as training programs, provision of pollution control infrastructure, and enhanced regulatory presence—to transition these informal hubs toward safer and more sustainable practices.

C. Environmental Impact

- *Soil Analysis*

Soil samples were collected from areas within or adjacent to active mechanic workshops, particularly from locations where oil spillage and dumping of metal and battery waste were observed. The samples taken near oil dumping sites in Apo, Karmo, and Jahi showed elevated levels of Total Petroleum Hydrocarbons (TPH), exceeding the safe thresholds set by FMEnv and NESREA. Heavy metals such as lead, cadmium, and zinc were also found in concentrations harmful to plant and microbial life, indicating long-term ecological risks.

Table 5: Soil Quality Results in Mechanic Clusters

Parameter	Apo	Gudu	Karmo	Jahi	Mabushi	FMEnv/NESREA Limit
Total Petroleum Hydrocarbons (TPH)	3,200 mg/kg	2,780 mg/kg	3,700 mg/kg	2,950 mg/kg	1,480 mg/kg	50
Lead (Pb)	560 mg/kg	610 mg/kg	390 mg/kg	590 mg/kg	230 mg/kg	85
Cadmium (Cd)	5.2 mg/kg	4.8 mg/kg	6.7 mg/kg	5.9 mg/kg	7.8 mg/kg	3
Zinc (Zn)	140 mg/kg	135 mg/kg	210 mg/kg	170 mg/kg	190 mg/kg	300
Chromium (Cr)	75 mg/kg	60 mg/kg	80 mg/kg	70 mg/kg	85 mg/kg	100
pH (unitless)	6.5 mg/kg	5.8 mg/kg	6.8 mg/kg	6.0 mg/kg	7.1 mg/kg	6.0–9.0

Source: Field Survey/Laboratory Analysis, 2025

TPH levels ranged between 1,480 mg/kg and 3,700 mg/kg, far exceeding the FMEnv soil quality guideline limit of 50 mg/kg. The highest concentration was found in Karmo and Apo, where used oil is frequently discharged directly into the soil. Lead (Pb Concentrations ranged from 230 mg/kg to 610 mg/kg, particularly high in Gudu and Jahi. This is substantially above the NESREA threshold of 85 mg/kg, indicating serious contamination from batteries and paints. Cadmium (Cd) Levels were detected between 2.4 mg/kg and 7.8 mg/kg, with the highest levels recorded in Mabushi, suggesting poor handling of scrap and electronic waste. pH values of the soils were slightly acidic to neutral (5.8–7.1), likely influenced by the degradation of hydrocarbons and acid-based cleaning fluids. Zinc and chromium were present in moderately elevated levels, likely from lubricants and worn brake pads.

- *Water Quality Analysis*

Water samples were taken from shallow wells and surface drains within 500 meters near mechanic activities in Mabushi and Karmo showed signs of contamination, including oily films, unpleasant odor, and elevated biochemical oxygen demand (BOD). In Gudu and Jahi, runoff from mechanic zones during the rainy season contributes to the pollution of nearby drains and streams, threatening aquatic life and downstream water users.

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Table 6: Water Quality Results Near Mechanic Clusters

Parameter	Apo	Gudu	Karmo	Jahi	Mabushi	NESREA/WHO Limit
TPH (mg/L)	3.6	2.8	3.2	3.0	1.2	0.5 mg/L (NESREA)
Lead (Pb, mg/L)	0.14	0.12	0.11	0.10	0.05	0.01 mg/L (WHO)
BOD (mg/L)	30	35	28	33	25	6 mg/L (NESREA)
COD (mg/L)	80	95	85	88	70	30 mg/L (NESREA)
Total Coliform (CFU/100ml)	Present	Present	Present	Present	Present	0 CFU/100ml (WHO)
E. coli (CFU/100ml)	Present	Present	Present	Present	Present	0 CFU/100ml (WHO)
pH	6.5	6.3	6.8	6.4	6.2	6.5–8.5 (WHO/NESREA)

TPH in surface water reached values of 1.2 mg/L to 3.6 mg/L, with the highest levels in Apo and Jahi, exceeding NESREA's limit of 0.5 mg/L for surface waters. BOD and COD levels indicated significant organic pollution, with BOD values as high as 35 mg/L and COD up to 95 mg/L, particularly in Gudu, where wastewater from engine washing is discharged into open drains. Lead concentrations in water ranged from 0.05 to 0.14 mg/L, higher than the WHO limit of 0.01 mg/L for drinking water, indicating leachate infiltration.

Microbial contamination (total coliforms and E. coli) was present in all samples, especially in Mabushi and Karmo, due to proximity to unlined soakaways and mixed waste disposal. pH levels in water ranged between 6.2 to 6.9, within acceptable limits but suggestive of mildly acidic conditions due to runoff mixing with industrial effluents.

➢ *Air Quality Analysis*

Air quality was measured using portable analyzers for common pollutants in auto repair zones: particulate matter (PM2.5 and PM10), volatile organic compounds (VOCs), and carbon monoxide (CO).

Table 7: Ambient Air Quality in Mechanic Clusters

Parameter	Apo	Gudu	Karmo	Jahi	Mabushi	WHO/NESREA Limit
PM10 (µg/m³)	130	176	112	150	170	50 µg/m³ (WHO, 24hr avg)
PM2.5 (µg/m³)	95	125	78	92	108	25 µg/m³ (WHO, 24hr avg)
Carbon Monoxide (CO, ppm)	18	27	15	20	23	30 ppm (NESREA, 1hr avg)
VOCs (e.g. Benzene, ppm)	High	Moderate	High	High	Moderate	<1 ppm (Benzene, WHO)

Air quality measurements in areas with routine open burning, especially in Gudu and Mabushi, revealed increased levels of particulate matter (PM2.5 and PM10), as well as the presence of VOCs such as benzene and toluene, which are known carcinogens.

PM2.5 and PM10 recorded concentrations ranged from 98 µg/m³ to 176 µg/m³ for PM10 and 62 µg/m³ to 125 µg/m³ for PM2.5, significantly above the WHO recommended limits of 50 µg/m³ (PM10) and 25 µg/m³ (PM2.5) for 24-hour exposure. The highest readings were recorded in Mabushi and Gudu, where tire burning and welding are common.

Carbon Monoxide (CO) levels ranged from 8 ppm to 27 ppm, approaching the NESREA hourly limit of 30 ppm, especially in enclosed or congested workshops with running engines.

VOCs Elevated concentrations of benzene, toluene, and xylene were found in Jahi and Karmo, attributed to frequent spray painting and open solvent use without proper ventilation or personal protective equipment (PPE).

➢ *Summary of Environmental Impact*

- Soil contamination from hydrocarbons and heavy metals is widespread, threatening plant life and exposing humans to direct contact or ingestion of toxic elements.
- Water quality is compromised by runoff and leachate from mechanic sites, endangering local water users and aquatic ecosystems.
- Air pollution from burning and exhaust fumes presents inhalation risks, especially for children and vulnerable populations living nearby.

These results clearly indicate that mechanic clusters in Abuja are hotspots for localized environmental degradation due to informal practices and lack of regulatory enforcement.

➢ *Sustainability Gaps*

This study identifies several critical sustainability gaps. First, there is a notable absence of physical infrastructure to support proper waste collection, segregation, and treatment. Abuja lacks dedicated waste transfer stations or treatment facilities tailored to the automotive repair industry. Second, there is a major deficit in environmental education and technical training. Most workshop operators and apprentices are unaware of the environmental consequences of their actions or of alternative, safer waste management practices.

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Financial constraints further hinder progress. Informal mechanics often operate on low margins, and investing in pollution control infrastructure or safe disposal services is perceived as unaffordable. Without incentives or subsidized programs, informal operators have little motivation to change existing practices.

Additionally, institutional coordination between municipal councils, NESREA, and local mechanic associations is weak. The lack of an inclusive policy framework that brings together regulators, waste handlers, and mechanic communities limits the scalability of any pilot interventions. While some clusters, such as Apo, have begun organizing themselves into cooperative groups, these initiatives remain fragmented and under-resourced.

In sum, the findings illustrate a deep-seated environmental management crisis in Abuja's mechanic clusters, driven by informality, regulatory gaps, and socio-economic challenges. The environmental footprint of these clusters especially their contribution to soil, water, and air pollution is both significant and growing.

VI. RECOMMENDATIONS

- *Improved Waste Management Practices*

A critical first step is the establishment of designated waste disposal and collection points within or near the clusters. These hubs should be managed either by municipal councils or in partnership with private waste management firms and community cooperatives. Such facilities would enable the safe collection, segregation, and treatment of hazardous and non-hazardous waste streams. Additionally, there should be a formal push to incentivize recycling of used oil, batteries, and vehicle parts through organized buyback programs or partnerships with recyclers. In places like Mabushi and Apo where some reuse and resale of oil is practiced, formalizing and scaling such efforts under regulated frameworks could significantly reduce indiscriminate dumping.

- *Public Awareness Campaigns*

Raising awareness about the environmental and health risks associated with improper waste disposal is essential. This can be achieved through regular training workshops, information campaigns, and sensitization outreach programs directed at mechanics, apprentices, and vehicle owners. These campaigns should focus on best practices for waste handling, spill prevention, and the long-term benefits of pollution control. Mechanic associations in these clusters can be leveraged as channels for peer-to-peer education, while media outlets and social platforms can amplify messaging to a broader audience. Government agencies and NGOs can collaborate to ensure materials are accessible, language-appropriate, and community-driven.

- *Infrastructure and Policy Support:*

For sustainable change to occur, it is imperative to provide the necessary infrastructure and policy support that empowers small and informal workshops to comply with environmental standards. This includes the provision of affordable waste containment units, spill kits, and safety gear, as well as technical assistance for building containment structures or installing basic oil traps. Additionally, financial incentives or microgrants could be provided to workshop operators who demonstrate compliance or commit to sustainable upgrades. Partnerships between local governments, NGOs, and donor agencies can help implement such programs while building community trust. For instance, the Abuja Environmental Protection Board (AEPB) could collaborate with vocational centers to integrate environmental management into auto-repair training curricula.

- *Strengthened Regulations and Enforcement:*

Lastly, there is a need for stronger monitoring, inspection, and enforcement of existing environmental regulations, particularly those under the purview of NESREA and the Federal Ministry of Environment. Mechanic clusters must be formally recognized within the environmental compliance structure, with clearly defined obligations and consequences for non-compliance. Establishing mobile inspection units and environmental task forces that routinely visit mechanic hubs can increase visibility and regulatory presence. Enforcement should be complemented by a graduated penalty system and support mechanisms, ensuring that regulation is both firm and fair encouraging improvement rather than penalizing poverty.

VII. CONCLUSION

This study evaluated environmental and waste management practices in five major mechanic clusters in Abuja (Apo, Gudu, Karmo, Jahi, and Mabushi). Findings show that waste disposal is largely informal, poorly regulated, and environmentally harmful. Practices such as dumping used oil, open burning, and unmanaged scrap disposal have led to soil and water pollution and pose health risks.

Pollution control measures are inadequate, with most workshops lacking basic containment, waste segregation, or safety gear. Only a few had any environmental training or interaction with regulators, underscoring major enforcement gaps. While some informal recycling occurs, it remains uncoordinated and ineffective.

The clusters face systemic issues lack of infrastructure, awareness, incentives, and regulation hindering sustainable practices. To address this, a multi-stakeholder approach is essential for Government must enforce regulations and provide waste management infrastructure. Private sector/NGOs should support training and eco-friendly technologies. Mechanic associations and communities need

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empowerment to adopt safer practices. With coordinated efforts, Abuja can reduce pollution, protect public health, and move toward a more sustainable urban environment.

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