

Research Article

Informal Sector E-waste Management in Aba Urban, South-eastern Nigeria: Assessment of Quantities Handled and Environmental-health Impacts

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Abstract

Rapid urbanization and the growing trade in second-hand electronics have intensified informal e-waste recycling in Nigerian cities. While coastal hubs such as Lagos and Port Harcourt have received considerable research attention, inland secondary hubs like Aba remain understudied despite their expanding role in national e-waste flows. This study aimed to assess the scale, practices, and health risks associated with informal e-waste processing in Aba. A mixed-methods approach was employed, combining structured questionnaires administered to 254 respondents, key informant interviews, GPS-tagged field observations, and volumetric waste assessments across five purposively selected hotspots. Quantitative data were analyzed using descriptive statistics in SPSS, and qualitative transcripts were thematically coded. Results showed that Ngwa Road, Ariaria Market, and Port Harcourt Road processed the highest volumes of hazardous waste, with cathode ray tubes and mobile phones dominating the waste stream. Informal recovery methods included manual dismantling, open-air cable burning, and occasional acid leaching, with minimal use of personal protective equipment. A risk-rating matrix classified 61% of workers as high-risk, with common health symptoms including respiratory distress, skin irritation, and eye discomfort. Spatial analysis indicated that most e-waste activities clustered within 2km of major commercial corridors, increasing local pollutant loads. The findings reveal significant gaps in Extended Producer Responsibility enforcement in inland Nigeria and underscore the need for targeted remediation, subsidized protective equipment, and integration of informal actors into regulated collection systems. By linking site-specific data from Aba to wider West African trends, the study provides evidence to support policy interventions aligned with Sustainable Development Goals 3, 8, 12, and 13.

Keywords

E-waste, Informal Recycling, Environmental Health, Spatial Analysis, Nigeria, Extended Producer Responsibility

1. Introduction

Electronic waste (e-waste) refers to discarded electrical and electronic equipment (EEE) that has reached the end of its functional life or been abandoned [1]. Globally, the accumulation of obsolete devices has emerged as one of the most

critical toxic waste challenges of the 21st century, with nearly nine out of ten households owning at least one outdated device often stored or improperly discarded [2]. The problem is symbolic in projects such as the WEEE Man, a seven-meter

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Received: 9 August 2025; **Accepted:** 18 August 2025; **Published:** 3 September 2025



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sculpture built entirely from discarded electronics, illustrating the rapid pace of technological obsolescence. This obsolescence is driven by rapid innovation cycles, frequent upgrades, and falling prices that expand global access to multifunctional devices [3].

While a portion of used electrical and electronic equipment (UEEE) imported into Nigeria is destined for legitimate reuse, mixed consignments frequently contain non-functional units that qualify as e-waste. The Person-in-the-Port (PiP) project estimated that between 2015 and 2016, approximately 60,000 metric tons of UEEE entered the country, of which about 19%

was non-functional [4]. Nigeria's National Environmental Standards and Regulations Enforcement Agency (NESREA) have implemented import guidelines restricting shipments to functional units. Nevertheless, informal-sector e-waste management remains largely unregulated, especially in inland cities, where data on environmental and health impacts are scarce. Globally, only 22% of the estimated 62 million tons of e-waste generated in 2022 was formally collected for environmentally sound recycling, with the remainder either undocumented or processed in jurisdictions with weak regulatory enforcement [1, 5].



Figure 1. Location of Aba (Nigeria Inset).

In Nigeria, over 1.1 million tons of e-waste are generated annually, with more than 90% handled informally [4]. While Lagos has well-documented hubs such as Alaba International Market, Ikeja Computer Village, and the Olusosun dumpsite, similar unregulated activities occur in other cities such as Port Harcourt, Kano, Ibadan, and Benin City, often involving hazardous methods like open-air cable burning and manual dismantling [6, 7].

Aba, in southeastern Nigeria, is a growing commercial centre with major e-waste hotspots at Ariaria Market, Ngwa Road, and Ukwu Mango [8, 9]. Informal recyclers frequently use unsafe techniques, releasing heavy metals and persistent

organic pollutants into the environment. Studies have recorded elevated copper (up to 21 mg/L) and lead (up to 5.6 mg/L) in water bodies in Aba [10, 11]. Despite the existence of Extended Producer Responsibility (EPR) frameworks, enforcement beyond Lagos remains weak, leaving secondary hubs like Aba overlooked.

While numerous studies have documented e-waste flows and associated risks in coastal Nigerian cities, inland commercial hubs remain poorly characterized with respect to waste volumes, recovery practices, and environmental-health implications. This study addresses this gap by quantifying the quantities and types of e-waste managed by the informal sector in Aba,

identifying recovery methods and evaluating their environmental and health risks, and documenting the spatial distribution of e-waste activities to guide targeted interventions.

2. Materials and Methods

2.1. Study Area

Aba is a major urban and commercial center located in Abia State, South-Eastern Nigeria. Geographically, it lies between latitudes 5°06'N and 5°08'N, and longitudes 7°21'E and 7°24'E (Figure 1). The city is situated on the Aba River and serves as a gateway between South-East and South-South Nigeria, making it a strategic location for trade and logistics.

With an estimated population of over 1.2 million as of 2023 [12, 13], Aba is one of Nigeria's most densely populated urban centers. The city comprises two major Local Government Areas-Aba North and Aba South-and is characterized by a mix of residential, industrial, and commercial land use.

Aba experiences a tropical monsoon climate (Am) under the Köppen-Geiger classification system. The annual average temperature ranges from 24°C to 32°C, and the city receives between 2,200 mm and 2,800 mm of rainfall annually. The rainy season typically spans from March to October, peaking between June and September, while the dry season lasts from November to February [10]. The high humidity and frequent rainfall often exacerbate environmental challenges associated with informal waste disposal and open-air dismantling.

Aba is renowned for its vibrant informal economy, particularly in small-scale manufacturing, repair, and electronics trading. The Ariaria International Market-one of the largest in West Africa-hosts thousands of traders involved in the sale, repair, and dismantling of electronic and electrical equipment. Informal recyclers, scavengers, and technicians operate throughout the city, often without environmental or occupational safeguards, contributing to the proliferation of informal e-waste hotspots.

These activities involve the open-air burning of cables, rudimentary metal extraction, and indiscriminate dumping of electronic components, often near drains and general waste sites. The environmental and public health implications are considerable, given the release of heavy metals and persistent organic pollutants (POPs) during these processes [14].

2.2. Sampling and Data Collection

A stratified random-quota sampling approach was adopted to capture perspectives from four key informal e-waste stakeholder groups: repairers/refurbishers, used electronics traders, scrap collectors/scavengers, and workshop apprentices/technicians. In total, 254 participants were engaged. Of these, 100 completed structured questionnaires, distributed as follows: 25 repairers/refurbishers, 25 traders, 30 scavengers, and 20

apprentices/technicians. The remaining participants contributed through semi-structured interviews and systematic observation.

To provide deeper insights, four key informant interviews were conducted with: (i) a senior repair shop owner, (ii) a female scrap dealer at the municipal dumpsite, (iii) a cable burner at Ukwu Mango, and (iv) a local public health nurse. Field observations, guided by a structured checklist, documented visible waste volumes, ash residues, smoke emissions, use (or non-use) of personal protective equipment (PPE), signs of acid leaching, and indicators of environmental contamination. These observations were complemented with GPS-tagged photographs and spatial documentation of e-waste activity sites.

2.3. E-waste Quantification and Recovery Analysis

Volumetric estimates of visible waste piles were calculated using the equations (1) and (2):

$$V = L \times W \times H \quad (1)$$

$$M = V \times \rho \quad (2)$$

Where: M = mass (kg), V = volume (m³) and ρ = bulk density of e-waste (assumed between 300-350kg/m³). Site-wide extrapolation was computed using equation (3):

$$Q_{total} = \sum Q_i \quad (3)$$

Where Q_i is the quantity processed per worker.

2.4. Environmental and Health Risk Assessment

The study employed a hazard-exposure-outcome model to analyze health impacts [15]. Environmental risk indicators included visible emissions from burning, air and soil contamination, and proximity to residences. Health outcomes were based on self-reported symptoms such as respiratory distress, fatigue, eye irritation, and skin problems.

A simplified risk-rating matrix was constructed by assigning:- A fixed exposure likelihood score of 3 (moderate exposure), - A severity score of 3 if at least one health symptom was reported, and 1 if none. The final risk rating was computed using equation (4):

$$\text{Risk Rating} = \text{Likelihood} \times \text{Severity} \quad (4)$$

3. Results

3.1. Stakeholder Characteristics and Participation

Figure 2 depicts the proportional distribution of the four

stakeholder groups that make up Aba's informal e waste economy. Of the 254 respondents, scrap collectors/scavengers constitute the single largest cohort (73 individuals, $\approx 28.7\%$), followed closely by repairers/refurbishers (70, $\approx 27.6\%$). Used electronics traders account for 57 respondents ($\approx 22.4\%$), while apprentices/technicians make up the remaining 54 ($\approx 21.3\%$).

The relatively narrow spread—only about seven percentage points separate the largest and smallest groups—indicate a balanced representation of the main actors who collectively drive e waste flows in the city. Scavengers dominate slightly, reflecting their frontline role in retrieving discarded devices

from dumpsites, roadside heaps, and household waste streams. Repairers/refurbishers form an almost equal proportion, underscoring the importance of refurbishment and parts harvesting before final dismantling. Traders, who broker second hand electronics and recovered components, and apprentices/technicians, who support repair shops and learn dismantling skills, together comprise just over two fifths of the sample. This distribution confirms that the study captured all critical links in the informal e waste value chain, thereby strengthening the validity of subsequent analyses on material recovery, occupational risk, and environmental impact.

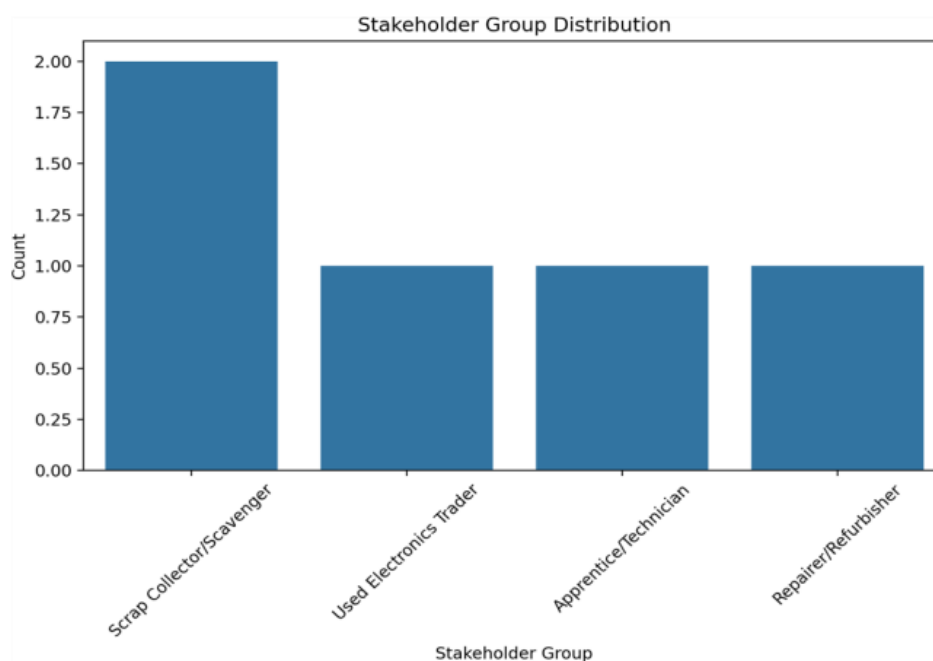


Figure 2. Stake Holder Group Distributions.

3.2. Quantities and Types of E-waste Managed

Quantitative analysis revealed that substantial volumes of e-waste are processed daily across Aba's informal recycling hotspots. The most active locations—Ngwa Road, Port Harcourt Road Dumpsite, Ariaria Market, Ukwu Mango, and adjoining roadside drainage systems—function as key nodes for e-waste accumulation and processing. These sites demonstrated consistently high daily throughput of obsolete devices, corroborated by both direct field observations and respondent self-reports.

Cathode Ray Tubes (CRTs) and mobile phones constituted the largest proportions of hazardous e-waste, followed by laptops and mixed-device categories lacking a dominant component type. Despite long-standing import restrictions,

CRTs persist in the local waste stream, likely sourced from residual stockpiles or informal cross-border flows, reflecting a continued dependence on outdated display technologies [ref]. In contrast, the prevalence of discarded mobile phones reflects the rapid expansion of compact electronics and their accelerated turnover cycles.

Spatial analysis indicated that Ngwa Road and the Port Harcourt Road Dumpsite consistently ranked among the most hazardous sites due to both waste volume and unsafe handling methods. Figures 3 and 4 illustrate these patterns: Figure 3 depicts the distribution of hazardous waste volumes across major sites, while Figure 4 presents average daily waste quantities reported by respondents. Collectively, these visualizations underscore not only the dominance of certain device types but also the uneven spatial burden of informal recycling activities in Aba.

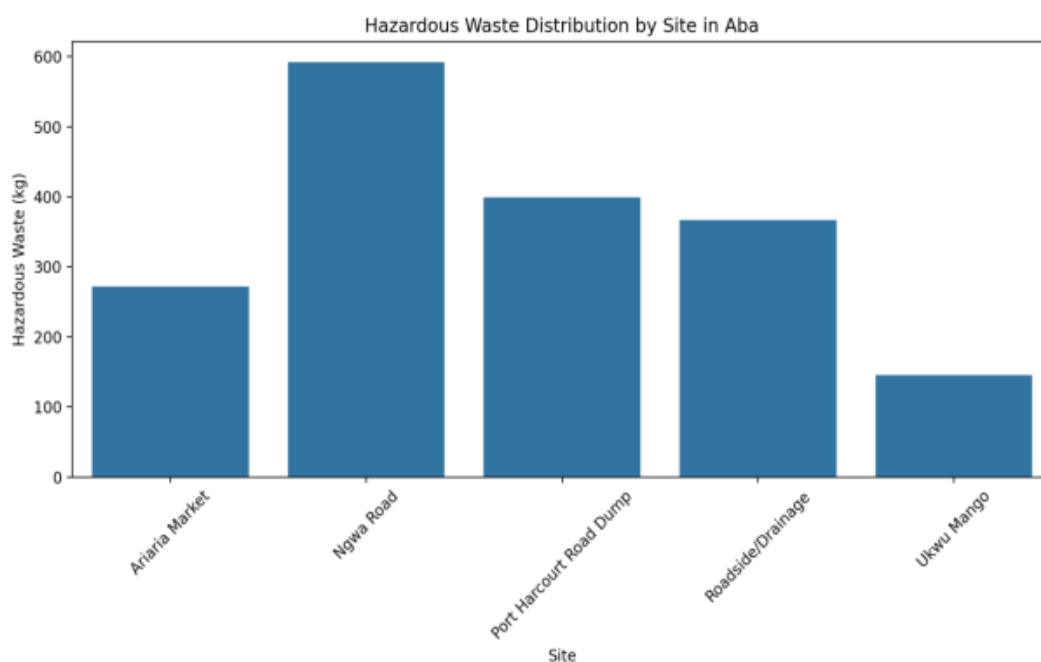


Figure 3. Hazardous Waste Distribution by sites in Aba.

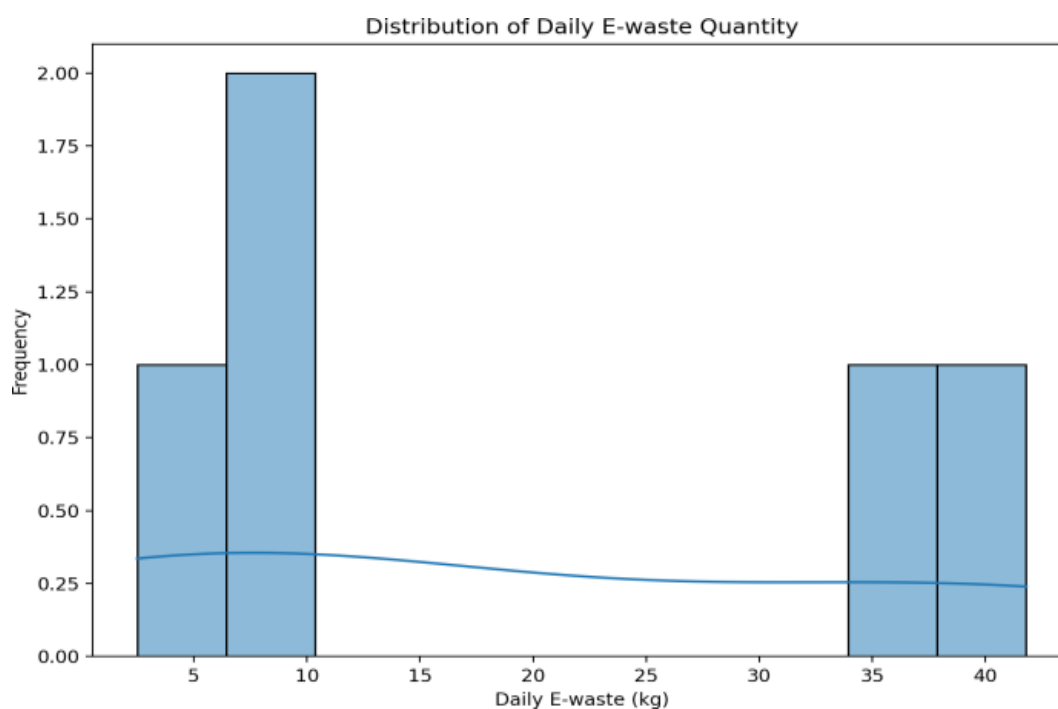


Figure 4. Distribution of Daily E-Waste Quantity.

3.3. Recovery Techniques and Material Extraction

Recovery techniques observed across the study sites included manual dismantling, open-air burning of cables for metal recovery (particularly copper), mechanical crushing, and acid-assisted extraction. These methods were predomi-

nantly employed without the use of protective gear, as confirmed through direct observation and participant responses.

Despite their efficiency in material recovery, these practices pose serious occupational hazards. For instance, cable burning—common at Ukwu Mango and Ngwa Road—emits toxic fumes, including dioxins and polycyclic aromatic hydrocarbons. Informants reported routine exposure to black smoke, pungent odors, and ash residues, which were corroborated by

field observations and spatial documentation. Port Harcourt Road Dumpsite, Ariaria Market, Ukwu Mango, and adjoining roadside drainage systems-function as key nodes for e-waste accumulation and processing. These sites demonstrated consistently high daily throughput of obsolete devices, corroborated by both direct field observations and respondent self-reports.

3.4. Environmental and Health Implications

To systematically assess health risks associated with e-waste recovery practices, a risk-rating matrix was developed. A uniform exposure likelihood score of 3 (moderate) was applied across respondents, while severity scores were assigned based on self-reported symptoms, including respiratory difficulty, skin irritation, fatigue, and eye discomfort. Individuals reporting one or more of these symptoms received a severity score of 3, whereas those without symptoms were assigned a score of 1 [16].

The resulting risk ratings ranged from 3 to 9, with a mean score of 6.66 and a median of 9. Overall, 155 respondents (61%) were categorized as high-risk (score > 6), while 99 (39%) were classified as low-risk (score ≤ 3). Notably, no participants fell within the moderate-risk category, indicating a polarized distribution of health outcomes. This suggests that informal e-waste workers are either substantially affected or minimally impacted, with little evidence of an intermediate-risk group.

Such polarization underscores the pervasive vulnerability of workers engaged in dismantling, burning, or acid-leaching practices, which expose them to toxic fumes, heavy metal residues, and persistent organic pollutants [17]. Among the symptoms reported, respiratory complications emerged as the most prevalent, reflecting the direct impact of inhaled pollutants generated by open-air cable burning and particulate matter from mechanical crushing. Figure 5 illustrates the distribution of respiratory health issues, which accounted for the largest proportion of reported symptoms.

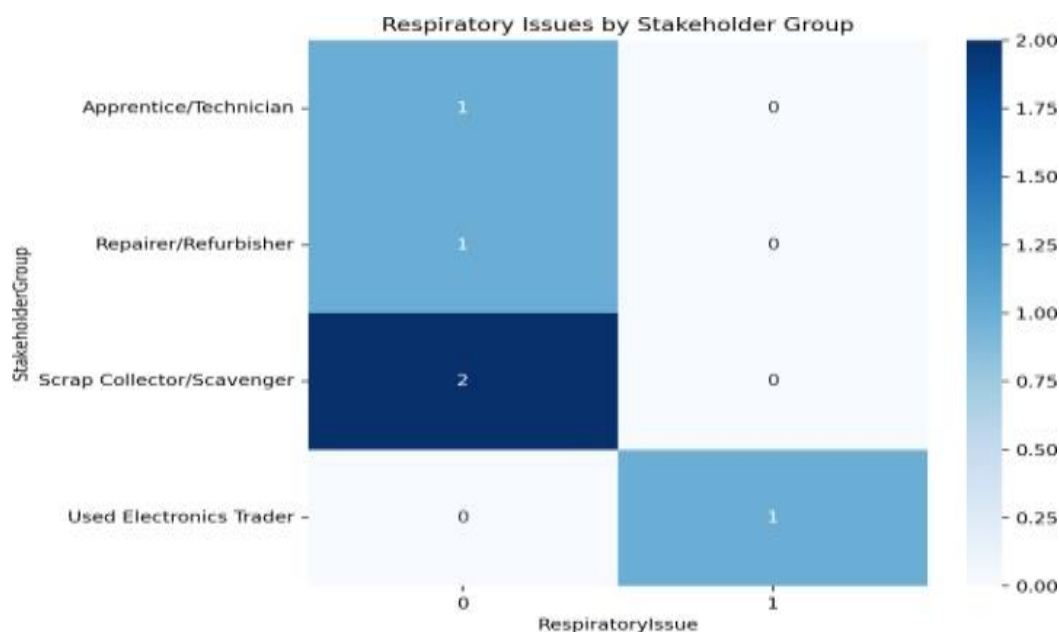


Figure 5. Respiratory Issues.

3.5. Spatial Patterns of E-waste Activity

GPS-tagged observations identified strong clustering of e-waste processing in Ariaria Market, Ngwa Road, and Ukwu Mango (Figures 6-8). These sites function as multi-purpose hubs for repair, dismantling, and material recovery, with fre-

quent overflow of waste into adjacent drains and roadways.

Spatial analysis confirms that informal e-waste economies in Aba are concentrated along dense commercial corridors, mirroring patterns in other West African cities. This clustering amplifies pollutant loads within a ~2 km radius, underscoring the need for targeted, site-specific interventions.



Figure 6. High - intensity e - waste dismantling and recovery site along Okigwe Road, Aba (Lat 5.1180° N, Lon 7.3615° E).



Figure 7. Cluster of informal electronics dismantling workshops at MCC Road, Aba (Lat 5.1277° N, Lon 7.3341° E).



Figure 8. Cluster of abandoned and dismantled refrigerators at MCC Road, Aba (Lat 5.1278° N, Lon 7.3339° E).

4. Discussion

The study confirms the presence of a heterogeneous informal workforce—repairers, traders, scavengers, and apprentices—similar to occupational structures reported in Lagos, Ibadan, and Port Harcourt [4]. Consistent with national surveys, only a minority of respondents (~43%) could name any form of personal protective equipment (PPE), and most relied on tacit, peer - based learning rather than formal training. This low awareness mirrors findings from [11], who documented inadequate occupational safety knowledge among Nigerian e-waste workers. The youthfulness of the cohort (mean age < 30 years) also parallels patterns in Agbogboshie, Ghana, where limited schooling was linked to unsafe handling practices [18].

Daily throughput estimates at Ngwa Road, Port Harcourt Road, and Ariaria Market align with national inflow studies showing ~60,000 tones of used electronics entering Nigeria annually, with 19-25% non-functional on arrival [19]. CRTs remain disproportionately represented in the waste stream, corroborating port inspection data and global statistics indicating their continued prevalence despite LCD dominance [20].

Observed recovery practices—manual dismantling, open-air cable burning, and occasional acid leaching—are consistent with “crude” recycling methods documented in Ghana’s former Agbogboshie hub [21]. The visual and olfactory evidence of black smoke plumes at Ukwu Mango matches transboundary patterns of pollutant release described in other West African contexts. Similar process chains have been reported in Kano and Benin City [22, 23] suggesting entrenched technological path dependence in Nigeria’s informal sector.

GIS mapping identified Ariaria, Ngwa Road, and Ukwu Mango as core activity clusters of e-waste. This pattern aligns with [24] observation that informal e-waste economies concentrate in dense commercial corridors where repair, resale, and dismantling co-occur. Similar agglomerations in Lagos’s Ikeja Computer Village and Ghana’s Agbogboshie have been shown to amplify pollutant loads within a 2 km radius. These findings argue for targeted, site-specific remediation zones rather than diffuse citywide interventions.

5. Conclusion

This study provides the first spatially explicit and empirically quantified assessment of informal e-waste management in Aba, Nigeria—a secondary urban hub largely absent from national e-waste literature. The findings reveal that hazardous recovery practices such as open-air cable burning, manual dismantling, and occasional acid leaching remain widespread, with minimal PPE use among workers. CRTs and mobile phones dominate the waste stream, reflecting both outdated technology reliance and rapid device turnover. Spatial analysis identified Ariaria Market, Ngwa Road, and Ukwu Mango

as concentrated hotspots where pollutant loads are likely to be highest.

The risk assessment classified 61% of informal workers as high risk, with respiratory distress, skin irritation, and ocular discomfort as the most common health symptoms. Heavy metal concentrations in local water bodies exceeded WHO guidelines, reinforcing parallels with contamination profiles documented in other West African e-waste sites. These results demonstrate that inland cities face environmental and health burdens comparable to coastal hubs, yet remain overlooked in current Extended Producer Responsibility (EPR) enforcement.

This study relied partly on self-reported estimates of waste volumes, which may be influenced by recall bias and subjective interpretation. In addition, chemical analysis was restricted to a subset of environmental samples, limiting the ability to generalize findings across all sites. Seasonal variations in e-waste flows and recovery practices were not assessed, meaning that temporal dynamics-such as fluctuations in waste volumes during peak trading periods-remain unaccounted for. These limitations highlight the need for more comprehensive, longitudinal approaches in future research.

Strengthening Extended Producer Responsibility (EPR) enforcement should be prioritized, particularly to cover inland secondary hubs that often escape regulatory oversight. Establishing controlled collection points and targeted remediation at identified processing hotspots would help reduce uncontrolled dumping and minimize contamination risks. Policy interventions should also extend to informal workers through the introduction of subsidies for safer practices and strict enforcement of personal protective equipment (PPE) usage.

From a research perspective, longitudinal biomonitoring is necessary to track long-term health impacts among workers routinely exposed to toxic emissions and residues. Further studies should also investigate seasonal patterns and the underlying economic drivers of e-waste flows into inland markets, as this would provide a more nuanced understanding of trade dynamics and associated risks. Together, these measures would strengthen both the policy framework and evidence base needed to address the complex challenges of informal e-waste management.

Acknowledgments

The author gratefully acknowledges the financial support of the Tertiary Education Trust Fund (TETFund) through the Institutional Based Research Grant No. TETFund/IBR/ABSU/2021/027, which made this study possible. Sincere appreciation is extended to all research participants for their time and insights, and to the field assistants who contributed to data collection, GPS mapping, and photographic documentation. Special thanks are also due to the staff of the National Environmental Standards and Regulations Enforcement Agency (NESREA) Aba Office for providing relevant background information, and to the Abia State Uni-

versity Department of [insert your department name] for logistical and administrative support throughout the project.

Author Contributions

Felix Ike is the sole author. The author read and approved the final manuscript.

Funding

This work is supported by Tetfund Institutional Based Research Grant No. TETFund/IBR/ABSU/2021/027.

Conflicts of Interest

The author declares no conflict of interest.

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