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AN ASSESSMENT OF WASTE GENERATION, COLLECTION, SEGREGATION AND DISPOSAL PRACTICES IN ABATTOIRS OF KANO METROPOLIS, NIGERIA

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Abstract **https://doi.org/10.65760/sjgs.v4.i2.12**

Abattoir waste is a significant environmental and public health concern in rapidly urbanizing cities, particularly where collection, segregation, treatment, and disposal systems are inadequate. This study assessed waste generation, collection, segregation, storage, and disposal practices and their associated environmental health risks in five major abattoirs in Kano Metropolis, Nigeria. A convergent parallel mixed-methods design was employed between March and August 2025. Structured questionnaires were administered to 357 abattoir workers, while 15 key informants interviews were conducted using purposive sampling technique and field observations were also conducted. Quantitative data were analyzed using descriptive statistics and an independent-samples t-test, while qualitative data were subjected to thematic analysis. Mixed waste streams were reported by 94.4% of respondents, with animal parts constituting the dominant solid waste source (97.5%) and blood (98.6%) and cleaning wastewater (96.9%) the predominant liquid waste streams. Only 49.9% reported daily waste collection, while private waste-management companies (39.8%) and internal abattoir staff (38.1%) were the principal collection actors. Major barriers included inadequate facilities (72.8%), insufficient training (68.3%), and high management costs (65.5%). Full segregation by waste type was practiced by only 27.5% of respondents, whereas 22.1% reported no segregation. Solid waste disposal was dominated by open piling (32.5%) and open decomposition (30.5%), while 40.3% of liquid waste was reportedly discharged directly into drains or watercourses without treatment. Respondents associated poor waste management with water pollution (94.1%), soil contamination (92.4%), vector proliferation (96.9%), and community exposure (99.4%). Environmental impact scores were significantly higher among respondents reporting improper waste management than among those reporting proper management (68.4 vs. 45.2; $t = -5.67$, $df = 355$, $p < .001$). The findings demonstrate substantial deficiencies in abattoir waste governance and infrastructure and highlight the need for integrated interventions combining source segregation, reliable collection, wastewater treatment, resource recovery, worker training, and regulatory enforcement. Strengthening these systems could reduce environmental exposure and improve occupational and community health protection in Kano Metropolis.

Keywords: *Abattoir Waste, Waste Segregation, Waste Disposal, Environmental Health Risk, Kano Metropolis*.

Introduction

Abattoirs are essential nodes in the urban meat supply chain, yet the slaughtering and dressing of livestock generate substantial volumes of organic, liquid, and hazardous by-products that, when poorly managed, pose serious threats to environmental quality and public health (Ogamba & Bukar,

2023). In rapidly urbanizing cities such as Kano Metropolis, Nigeria, with a population exceeding four million, abattoir waste streams including blood, rumen and paunch content, bones, hooves, condemned tissue, and wash-water are frequently discharged with little or no treatment, contributing to surface and groundwater contamination, offensive odours, and the proliferation of disease vectors (Adebowale, 2020).

National estimates suggest that Kano's abattoirs alone generate approximately 2,361 tonnes of solid waste annually, much of which is released untreated into surrounding streams and open drains where pathogenic bacteria thrive (Ogamba & Bukar, 2023). Numerous studies conducted across Nigeria identify inadequate waste management, rather than waste volume per se, as the principal driver of the environmental and health risks associated with slaughterhouse operations (Ezeoha & Ugwuishiwu, 2021; Ibrahim et al., 2021). Deteriorating slaughter facilities, insufficient clean water supply, absent refrigeration, and a chronic lack of sewage and waste-treatment infrastructure compound the problem, resulting in the routine direct dumping of waste into rivers, a widespread practice across Nigerian cities (Nwanta et al., 2008; Ibrahim et al., 2021).

Despite the scale of the problem, comprehensive, facility-level evidence on how waste is actually generated, collected, segregated, and disposed of within Kano Metropolis abattoirs, and on the specific environmental health consequences that follow from current practice, remains limited. Most existing studies have addressed isolated aspects of abattoir operations such as hazard awareness (Auwal et al., 2021), infrastructure (Ali, 2018), or general sanitation (Yakubu et al., 2019) without integrating waste-stream analysis with measurable environmental health outcomes across multiple facilities. This study addresses that gap by examining waste generation, collection, segregation, and disposal practices, and their associated environmental health risks, across the five major abattoirs of Kano Metropolis.

The study sought to answer the following questions: (i) What types and sources of waste are generated within Kano Metropolis abattoirs? (ii) What methods are employed for waste collection, segregation, and disposal within the abattoir premises? (iii) What environmental health risks are associated with current waste handling and disposal practices? Accordingly, the overarching problem this study addresses is that despite the substantial volume and hazardous composition of abattoir waste generated daily in Kano Metropolis, prevailing collection, segregation, and disposal practices remain largely informal and untreated, sustaining serious risks to environmental integrity and the health of workers and surrounding communities in one of Nigeria's most populous urban centres.

Materials and Methods

This study adopted a convergent parallel mixed-methods descriptive design, grounded in pragmatism, to examine waste generation, collection, segregation, and disposal practices, and their associated environmental health risks, in the five largest abattoirs of Kano Metropolis (Kumbotso, Unguwa Uku, Bachirawa, Tudun Wada, and Kano Central). Kano Metropolis lies between latitudes 11°05'N and 12°07'N and longitudes 8°23'E and 8°47'E, covering approximately 499 km² and supporting a dense, rapidly urbanizing population whose meat demand sustains substantial daily abattoir throughput (Isma'il, 2019). The metropolis is drained chiefly by the River Jakara and River Kano, into which untreated abattoir effluent is frequently discharged, while its tropical wet-and-dry climate, with a short rainy season (May–October) and a long, hot dry season, intensifies both pathogen survival during the rains and dust-borne contamination during the harmattan (Olofin, 2018; Yahaya & Sani, 2023).

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The target population comprised 7,300 workers across the five abattoirs, of which 365 were sampled using the Krejcie and Morgan (1970) criteria, applying proportional stratified sampling and simple random sampling across job categories; 357 valid responses were analyzed. Fifteen key informants, comprising traditional heads of butchers (Sarakunan Pawa), chairmen of the butchers' association, and public health/veterinary officers, were purposively selected, bringing the combined sample to 380 participants. Data were collected between March and August 2025 using digitally administered structured questionnaires (via KoboCollect), in-depth semi-structured interviews, physical observation of waste collection, storage, and disposal points, and structured observation checklists, supported by trained enumerators and daily quality checks. Figure 1 indicates the location of the various slaughterhouses in the Kano metropolis. The aim of this figure is to provide an accurate, geographical image of the distribution of these abattoirs in the city. This is significant since, according to the study, a significant number of these facilities are situated near residential areas. Demonstrating their exact positions can be used to demonstrate the possible health hazards, including pollution and offensive smells, on surrounding communities. The map is basically used to give the reader the physical setting of the study and why the operations of the abattoirs are an issue of concern to the workers and the people around the abattoirs.

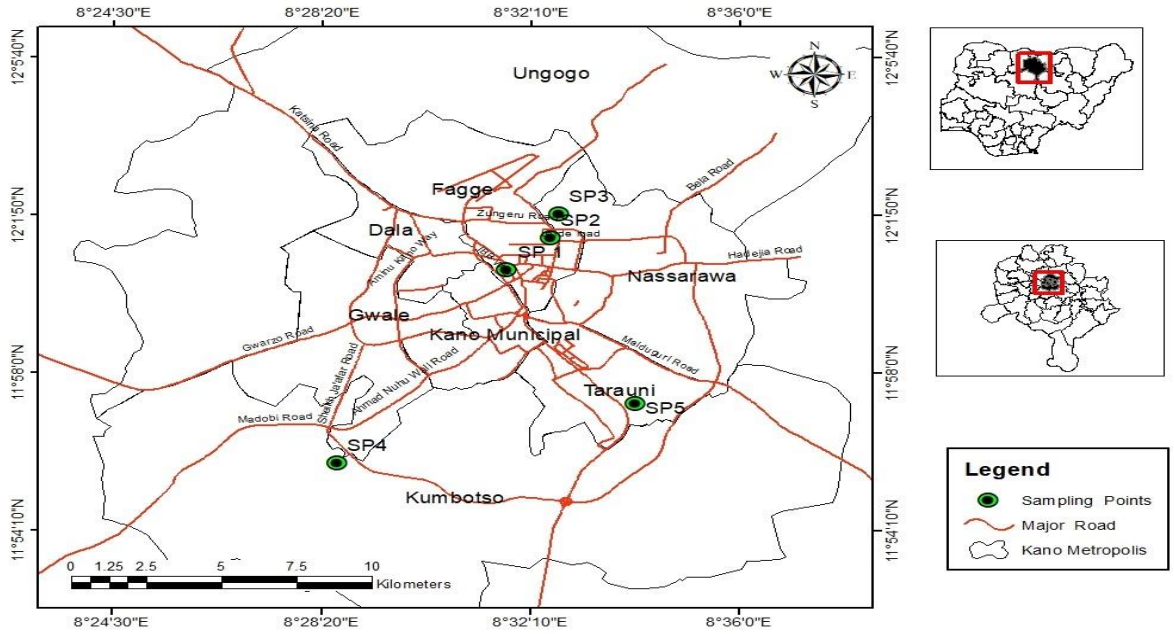

Figure: Map Showing the Location of Abattoirs in Kano Municipal
Source: Bayero University, Kano Geographic and Metrological Department

Table 1: Population of the Study based on Abattoirs

S/N	Abattoir	No of Workers	Percentage	Sample Size
1	Kumbotso abattoir	1400	19	69
2	Unguwa uku abattoir	1250	17	62
3	Bachirawa abattoir	1365	19	69
4	Tudun Wada abattoir	1196	16	58
5	Kano Central abattoir	2089	29	106
	Total	7280	100	365

Source: Reconnaissance Survey (2024)

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Descriptive statistics (frequencies and percentages) were used to characterize waste types, sources, and management practices, while an independent samples t-test was applied to compare environmental impact scores between facilities classified as practicing proper versus improper waste management, in order to test the hypothesis that waste handling methods have a measurable environmental impact. Qualitative data from key informant interviews were subjected to thematic analysis. Ethical procedures, including informed consent, confidentiality, and institutional introduction letters, were followed throughout, consistent with the broader study from which this paper is drawn.

Results and Discussions

Types and Sources of Waste Generated

Abattoirs across the five study locations overwhelmingly generate a combination of hazardous waste, with 94.4% of respondents confirming mixed waste streams, while only small proportions reported solid waste only (3.4%) or liquid waste only (2.2%) (Table 2). This indicates that slaughtering activities at Bachirawa, Tudun Wada, Kano Central, Kumbotso, and Unguwa Uku simultaneously produce blood, wastewater, dung, bones, rumen content, and other solid remains, rather than discrete, separable waste streams.

Table 2: Types of Waste Generated in the Abattoir

Study Area	Solid only	Liquid only	Hazardous (mixed)	Total
Bachirawa	2 (3.2%)	2 (3.2%)	59 (93.7%)	63 (100%)
Tudun Wada	2 (3.1%)	1 (1.5%)	62 (95.4%)	65 (100%)
Kano Central	3 (3.9%)	2 (2.6%)	72 (93.5%)	77 (100%)
Kumbotso	3 (4.6%)	2 (3.1%)	60 (92.3%)	65 (100%)
Unguwa Uku	2 (2.4%)	1 (1.2%)	82 (96.5%)	85 (100%)
Total	12 (3.4%)	8 (2.2%)	337 (94.4%)	357 (100%)

Source: Field Survey (2025)

Animal parts, comprising bones, offal, hooves, and horns, were by far the dominant source of solid waste (97.5% overall), followed by packaging materials (58.8%) and general trash (52.1%) (Table 3). Recognition of animal parts as the primary solid-waste source was consistently high across all sites (96.9–98.7%), corroborating Ogunbiyi et al. (2024) in Ogun State (98–99%) and Nyamongo et al. (2025) in Dar es Salaam (97%). On the liquid side, blood (98.6%) and cleaning wastewater (96.9%) were almost universally identified as the dominant streams, with chemical runoff cited by just over half of respondents (52.7%) (Table 4), a pattern that closely replicates findings from Adeyemi et al. (2024) in Ibadan and Woldemariam et al. (2025) in Mekelle, Ethiopia.

Table 3: Main Sources of Solid Waste by Study Area (Multiple Response)

Study Area	Animal parts	Packaging materials	General trash	Other
Bachirawa	62 (98.4%)	36 (57.1%)	32 (50.8%)	5 (7.9%)
Tudun Wada	64 (98.5%)	40 (61.5%)	36 (55.4%)	4 (6.2%)
Kano Central	76 (98.7%)	48 (62.3%)	42 (54.5%)	5 (6.5%)
Kumbotso	63 (96.9%)	36 (55.4%)	34 (52.3%)	8 (12.3%)
Unguwa Uku	83 (97.6%)	50 (58.8%)	42 (49.4%)	6 (7.1%)
Total	348 (97.5%)	210 (58.8%)	186 (52.1%)	28 (7.8%)

Source: Field Survey (2025)

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Table 4: Main Sources of Liquid Waste by Study Area (Multiple Response)

Study Area	Blood	Cleaning wastewater	Chemical runoff	Other
Bachirawa	62 (98.4%)	60 (95.2%)	32 (50.8%)	4 (6.3%)
Tudun Wada	64 (98.5%)	64 (98.5%)	36 (55.4%)	3 (4.6%)
Kano Central	77 (100%)	76 (98.7%)	42 (54.5%)	4 (5.2%)
Kumbotso	64 (98.5%)	62 (95.4%)	34 (52.3%)	6 (9.2%)
Unguwa Uku	85 (100%)	84 (98.8%)	44 (51.8%)	5 (5.9%)
Total	352 (98.6%)	346 (96.9%)	188 (52.7%)	22 (6.2%)

Source: Field Survey (2025)

Waste Collection Practices

Daily waste collection occurred in only 49.9% of cases, with a further 28.6% collected multiple times weekly, yielding 78.5% at least twice-weekly removal overall (Table 5). Collection frequency was highest in Kano Central (62.3% daily) and Tudun Wada (58.5% daily), but fell to 36.9% daily in Kumbotso, where 32.3% reported only weekly or as-needed collection. This pattern mirrors evidence from Ibrahim et al. (2023) in northern Nigeria (60–65% daily collection in municipal abattoirs versus 35–40% in peripheral sites) and Chaka et al. (2024) in Ethiopia (62% versus 34%), suggesting that reliance on informal collectors and constrained budgets prolong on-site waste accumulation in traditional, less-regulated facilities.

Table 5: Frequency of Waste Collection by Study Area (n = 357)

Study Area	Daily	Multiple times/week	Weekly	Rarely/as needed	Total
Bachirawa	30 (47.6%)	18 (28.6%)	10 (15.9%)	5 (7.9%)	63 (100%)
Tudun Wada	38 (58.5%)	18 (27.7%)	6 (9.2%)	3 (4.6%)	65 (100%)
Kano Central	48 (62.3%)	20 (26.0%)	6 (7.8%)	3 (3.9%)	77 (100%)
Kumbotso	24 (36.9%)	20 (30.8%)	14 (21.5%)	7 (10.8%)	65 (100%)
Unguwa Uku	38 (44.7%)	26 (30.6%)	12 (14.1%)	9 (10.6%)	85 (100%)
Total	178 (49.9%)	102 (28.6%)	48 (13.4%)	29 (8.1%)	357 (100%)

Source: Field Survey (2025)

Responsibility for waste collection was split between private waste management companies (39.8%), internal abattoir staff (38.1%), and government agencies (17.4%), with 4.8% of respondents reporting no designated collection team at all (Table 6). Private companies dominated in Kano Central (49.4%) and Tudun Wada (46.2%), whereas internal staff handled collection more often in Kumbotso (46.2%), reflecting the exclusion of peripheral, unregistered facilities from formal municipal or private waste contracts, a pattern consistent with Ogunbiyi et al. (2024) and Woldemariam et al. (2025).

Table 6: Responsibility for Waste Collection in the Abattoir

Study Area	Internal staff	Private companies	Government agencies	No team	Total
Bachirawa	26 (41.3%)	22 (34.9%)	12 (19.0%)	3 (4.8%)	63(100%)
Tudun Wada	24 (36.9%)	30 (46.2%)	10 (15.4%)	1 (1.5%)	65(100%)
Kano Central	26 (33.8%)	38 (49.4%)	12 (15.6%)	1 (1.3%)	77(100%)
Kumbotso	30 (46.2%)	18 (27.7%)	14 (21.5%)	3 (4.6%)	65(100%)
Unguwa Uku	30 (35.3%)	34 (40.0%)	14 (16.5%)	7 (8.2%)	85(100%)
Total	136 (38.1%)	142 (39.8%)	62 (17.4%)	17 (4.8%)	357(100%)

Source: Field Survey (2025)

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Lack of facilities was the most cited barrier to effective waste handling overall (72.8%), followed by insufficient training (68.3%) and high cost (65.5%) (Table 7), with Kumbotso consistently reporting the most severe challenges across all categories. These barriers corroborate the framework proposed by Mbanga et al. (2022), who argue that ineffective hazardous waste management in sub-Saharan Africa is fundamentally an infrastructural deficit, compounded by inadequate training and financing, which together sustain a cycle of non-compliance.

Table 7: Challenges in Handling Waste in the Abattoir

Study Area	Lack of facilities	Insufficient training	High cost	Lack of enforcement
Bachirawa	48 (76.2%)	44 (69.8%)	42 (66.7%)	40 (63.5%)
Tudun Wada	44 (67.7%)	40 (61.5%)	38 (58.5%)	36 (55.4%)
Kano Central	50 (64.9%)	46 (59.7%)	44 (57.1%)	42 (54.5%)
Kumbotso	56 (86.2%)	54 (83.1%)	52 (80.0%)	50 (76.9%)
Unguwa Uku	62 (72.9%)	60 (70.6%)	58 (68.2%)	56 (65.9%)
Total	260 (72.8%)	244 (68.3%)	234 (65.5%)	224 (62.7%)

Source: Field Survey (2025)

Waste Segregation and Storage Practice

Proper segregation by waste type (organic, non-organic, hazardous) was practiced by only 27.5% of respondents overall, while 31.4% separated only organic from non-organic waste, and 22.1% practiced no segregation at all (Table 8). Full segregation reached 39.0% in Kano Central but fell to 18.5% in Kumbotso, where 38.5% reported no segregation whatsoever. This low and uneven adoption mirrors regional patterns: Nyamongo et al. (2025) in Dar es Salaam observed 35–42% proper segregation in municipal abattoirs versus 15–20% in informal ones, while Adesina et al. (2023) in Lagos found a comparable 40% versus 22% split, both attributing the gap to the absence of designated containers and weak enforcement in traditional slaughter slabs.

Table 8: Waste Segregation Practices in the Abattoir

Study Area	By type	Org./non-org. only	Haz./non-haz. only	No segregation	Total
Bachirawa	16 (25.4%)	20 (31.7%)	12 (19.0%)	15 (23.8%)	63(100%)
Tudun Wada	24 (36.9%)	22 (33.8%)	14 (21.5%)	5 (7.7%)	65(100%)
Kano Central	30 (39.0%)	26 (33.8%)	14 (18.2%)	7 (9.1%)	77(100%)
Kumbotso	12 (18.5%)	16 (24.6%)	12 (18.5%)	25 (38.5%)	65(100%)
Unguwa Uku	16 (18.8%)	28 (32.9%)	16 (18.8%)	25 (29.4%)	85(100%)
Total	98 (27.5%)	112 (31.4%)	68 (19.0%)	79 (22.1%)	357(100%)

Source: Field Survey (2025)

Pre-disposal storage was likewise predominantly unhygienic, with open dumping the single most common storage method (43.1%), followed by open containers (31.9%) (Table 9). This means most facilities store highly putrescible waste in ways that expose it to pests, weather, and scavengers, a finding consistent with Akinro et al. (2009), who identified improper on-site storage as a primary driver of pollution, odour nuisance, and disease-vector proliferation in Nigerian abattoirs.

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Table 9: Storage Facilities for Waste Before Disposal (n = 357)

Study Area	Open dumping	Open container	Piled in area	Temp. storage	Total
Bachirawa	26 (41.3%)	20 (31.7%)	12 (19.0%)	5 (7.9%)	63 (100%)
Tudun Wada	34 (52.3%)	18 (27.7%)	10 (15.4%)	3 (4.6%)	65 (100%)
Kano Central	44 (57.1%)	20 (26.0%)	10 (13.0%)	3 (3.9%)	77 (100%)
Kumbotso	20 (30.8%)	24 (36.9%)	16 (24.6%)	5 (7.7%)	65 (100%)
Unguwa Uku	30 (35.3%)	32 (37.6%)	16 (18.8%)	7 (8.2%)	85 (100%)
Total	154 (43.1%)	114 (31.9%)	64 (17.9%)	25(7.0%)	357 (100%)

Source: Field Survey (2025)

Disposal Methods and Environmental Health Risks

Final disposal of solid waste was dominated by unsustainable practices, with piling in open areas the most common (32.5%) and open decomposition close behind (30.5%), while more controlled options such as incineration (21.8%) and composting (14.6%) remained underutilized (Table 10). For liquid waste, the most common disposal pathway was direct discharge into drains or watercourses (40.3%), with only 19.6% of facilities routed through any treatment plant; direct discharge peaked in Kumbotso (55.4%) and Unguwa Uku (47.1%) (Table 11). This widespread release of untreated effluent confirms warnings from UN-Habitat (2020) that inadequate wastewater management is a critical driver of surface and groundwater pollution, exposing both aquatic ecosystems and public health to pathogens, heavy metals, and organic pollutants.

Table 10: Disposal Method for Solid Waste

Study Area	Composting	Incineration	Pile in area	Open decomposition	Total
Bachirawa	8 (12.7%)	12 (19.0%)	20 (31.7%)	23 (36.5%)	63 (100%)
Tudun Wada	12 (18.5%)	18 (27.7%)	24 (36.9%)	11 (16.9%)	65 (100%)
Kano Central	16 (20.8%)	22 (28.6%)	28 (36.4%)	11 (14.3%)	77 (100%)
Kumbotso	6 (9.2%)	10 (15.4%)	18 (27.7%)	31 (47.7%)	65 (100%)
Unguwa Uku	10 (11.8%)	16 (18.8%)	26 (30.6%)	33 (38.8%)	85 (100%)
Total	52 (14.6%)	78 (21.8%)	116(32.5%)	109 (30.5%)	357(100%)

Source: Field Survey (2025)

Table 11: Liquid Waste Disposal Pathways

Study Area	Treatment plant	Filtered then disposed	Direct discharge	Stored in tanks	Total
Bachirawa	10 (15.9%)	16 (25.4%)	28 (44.4%)	9 (14.3%)	63 (100%)
Tudun Wada	18 (27.7%)	22 (33.8%)	20 (30.8%)	5 (7.7%)	65 (100%)
Kano Central	24 (31.2%)	28 (36.4%)	20 (26.0%)	5 (6.5%)	77 (100%)
Kumbotso	6 (9.2%)	12 (18.5%)	36 (55.4%)	11 (16.9%)	65 (100%)
Unguwa Uku	12 (14.1%)	18 (21.2%)	40 (47.1%)	15 (17.6%)	85 (100%)
Total	70 (19.6%)	96 (26.9%)	144 (40.3%)	47 (13.2%)	357 (100%)

Source: Field Survey (2025)

Improper waste disposal was associated with severe and near-universal environmental health consequences across all five study areas (Table 12). Almost every abattoir was linked to water pollution (94.1%), soil contamination (92.4%), and vector proliferation, with flies and mosquitoes attracted in 96.9% of cases. Air pollution from odour and smoke affected 89.4% of facilities, zoonotic disease transmission risk was reported in 76.5% of cases, and community-level exposure to

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these hazards was reported in nearly all abattoirs (99.4%). These findings align closely with Adeyemo (2008) in Ibadan and Nwanta et al. (2011) in Enugu, who documented comparable water and soil pollution from untreated blood and wastewater, and with Grace et al. (2020) and Alonge (2022), who linked poor abattoir waste handling to elevated zoonotic disease risk, including brucellosis and anthrax.

Table 12: Environmental Health Risks Associated with Improper Waste Disposal

Study Area	Water pollution	Air pollution	Soil contam.	Vector prolif.	Zoonotic risk	Community exposure
Bachirawa	59 (93.7%)	55 (87.3%)	57 (90.5%)	61 (96.8%)	48 (76.2%)	63 (100%)
Tudun Wada	61 (93.8%)	58 (89.2%)	60 (92.3%)	63 (96.9%)	50 (76.9%)	65 (100%)
Kano Central	73 (94.8%)	70 (90.9%)	72 (93.5%)	75 (97.4%)	59 (76.6%)	77 (100%)
Kumbotso	62 (95.4%)	59 (90.8%)	61 (93.8%)	64 (98.5%)	51 (78.5%)	65 (100%)
Unguwa Uku	81 (95.3%)	77 (90.6%)	80 (94.1%)	83 (97.6%)	65 (76.5%)	85 (100%)
Total	336(94.1%)	319(89.4%)	330(92.4%)	346(96.9%)	273(76.5%)	355 (99.4%)

Source: Field Survey (2025)

Stakeholder Perspectives on Waste Management Practices

Key informants from abattoir supervision and regulatory bodies described prevailing waste management practices characterized by the collection of solid waste, including bones, hooves, horns, and paunch content, in bins or temporary heaps for eventual transport to municipal landfills or designated dumpsites, while liquid waste, primarily blood and wash-water, is routinely discharged untreated into open drains or nearby channels. Open dumping of both solid and liquid waste was estimated to persist at approximately 30% of facilities, resulting in direct contamination of surface and groundwater and broader pollution of surrounding communities.

> *"Solid wastes such as bones, hooves, and paunch contents are supposed to be collected in bins and transported to municipal landfills, while liquid wastes, mainly blood and wash water, are discharged untreated into open drains. However, open dumping of both solid and liquid wastes still occurs at approximately 30% of the city's slaughter facilities, leading to direct contamination of surface and groundwater. The abattoir is currently implementing plans to construct a functional wastewater treatment plant and introduce blood recycling, with the target of reducing environmental pollution by at least 50% within the next few years." Supervisor, Tudun Wada Abattoir (2025).*

> *"Most abattoirs in the metropolis collect solid waste in temporary heaps before being evacuated, while liquid wastes are discharged untreated directly into nearby drainage channels. The absence of any form of wastewater treatment remains the primary cause of persistent water pollution and offensive odours affecting surrounding communities. With adequate funding and technical support, viable recycling initiatives such as bone-meal processing and biogas digesters for paunch content could significantly reduce both solid and liquid waste volumes." Senior Official, NESREA Kano Zonal Office (2025).*

These interview accounts corroborate the quantitative findings on direct liquid discharge and reliance on open dumping or landfilling for solids, with the 30% open-dumping estimate offering a grounded quantification of non-compliance. Proposed waste-to-resource interventions, including treatment plants, blood and bone-metal recycling, biogas digestion, and composting, echo recommendations from Nigerian studies advocating sustainable abattoir waste technologies (Ezeoha & Ugwuishiwu,

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2011; Chukwu et al., 2011), although the recurrent emphasis placed by informants on funding barriers reinforces inadequate infrastructure as the predominant constraint to implementation.

Test of Hypothesis

Hypothesis 4 stated that the methods used for waste collection, disposal, and treatment within the abattoir premises have a notable environmental impact due to improper waste management practices. An independent samples t-test was used to compare environmental impact scores between facilities classified as practicing proper versus improper waste management.

Table 13: Independent Samples T-Test of Environmental Impact by Waste Management Practice

Group	N	Mean Impact Score	SD	t-value	df	p-value	Decision
Proper Waste Management	78	45.2	12.5	-5.67	355	0.000	Significant
Improper Waste Management	279	68.4	15.3				

Source: Field Survey (2025)

The t-test results ($t = -5.67$, $p = 0.000$) confirm a statistically significant difference in environmental impact scores between abattoirs practicing proper versus improper waste management. The substantially higher mean impact score recorded for improper practices (68.4) relative to proper practices (45.2) supports rejection of the null hypothesis, in line with Olanrewaju and Udoma (2023) and FAO (2022), and indicates an urgent need for improved waste segregation and treatment infrastructure to mitigate pollution.

Discussions

The finding that abattoirs generate predominantly mixed, hazardous waste streams rather than cleanly separable solid and liquid fractions reflects the inherent nature of slaughtering operations, where blood, fluids, and solid remains are produced simultaneously on undivided floor surfaces. This finding is consistent with Bello et al. (2018) and Adewoye and Adewumi (2019), who similarly observed that urban Nigerian abattoirs typically generate highly organic, combined waste streams that are difficult to separate without dedicated infrastructure, underscoring that waste-stream complexity, not merely volume, is what drives downstream management difficulty.

The low and inconsistent rate of waste segregation found in this study, particularly the steep drop-off in peripheral facilities such as Kumbotso, mirrors a consistent regional pattern documented by Nyamongo et al. (2025) in Tanzania, Woldemariam et al. (2025) in Ethiopia, and Adesina et al. (2023) in Lagos, all of whom attribute the urban-peripheral gap to the absence of designated containers, space constraints, and weak enforcement in traditional slaughter facilities. This convergence across multiple national contexts suggests that segregation failure in informal abattoirs is a structural, not merely behavioral, problem, requiring infrastructural investment rather than awareness campaigns alone.

The dominance of open dumping, open decomposition, and untreated direct discharge as the principal disposal pathways, despite the near-universal recognition by respondents of the resulting water pollution, vector proliferation, and community exposure, illustrates a clear disjuncture between hazard awareness and practice change in the absence of enforced alternatives. This pattern is

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consistent with Adelekan and Ogundele (2011) and Ikpeazu and Ogbonna (2016), who both identified the underutilization of composting and incineration in Nigeria as a missed opportunity for resource recovery rather than a simple consequence of ignorance. The statistically significant difference in environmental impact scores between proper and improper waste management practices observed in this study, together with corroborating qualitative accounts from regulators and supervisors, reinforces that targeted infrastructural interventions, including blood and bone-meal recycling, biogas digestion of paunch content, and centralized wastewater treatment, represent the most direct route to reducing the environmental health burden of abattoir operations in Kano Metropolis.

Conclusion

This study set out to examine waste generation, collection, segregation, and disposal practices, and their associated environmental health risks, in the five major abattoirs of Kano Metropolis. The findings show that abattoirs generate predominantly mixed, hazardous waste streams dominated by animal parts, blood, and wash-water; that collection remains inconsistent and informally organized, hampered by lack of facilities, insufficient training, and high cost; that proper waste segregation is practiced by little more than a quarter of facilities; and that final disposal relies heavily on open dumping, open decomposition, and untreated direct discharge, practices statistically confirmed to carry a significantly greater environmental impact than proper waste management. These conditions sustain water and soil pollution, vector proliferation, and elevated zoonotic disease risk affecting both workers and the surrounding community. Addressing these gaps requires mandatory waste segregation at source, investment in composting, biogas, and centralized wastewater treatment infrastructure, formalization of collection responsibilities, and strengthened regulatory inspection, all of which are essential to safeguarding environmental integrity and public health in Kano Metropolis.

Recommendations

1. Kano State Ministry of Environment and Climate Change, in collaboration with relevant environmental regulatory agencies (e.g. NESEREA), should strengthen routine inspection and enforcement of waste-management standards in all abattoirs within Kano Metropolis. Particular attention should be given to preventing open dumping, uncontrolled decomposition, and the discharge of untreated liquid waste into drains and watercourses.

2. Kano State Ministry of Agriculture and Natural Resources and the abattoir management authorities should require all abattoirs to establish mandatory waste segregation at source, with clearly labelled containers for organic, recyclable, hazardous, and other waste streams. Compliance should form part of routine abattoir inspection and licensing.

3. Kano State Government and abattoir management authorities should invest in appropriate waste-treatment infrastructure, particularly centralized wastewater treatment systems, composting facilities, anaerobic digesters for biogas production, and facilities for the recovery of useful products such as bone meal. These interventions would reduce uncontrolled disposal while creating opportunities for resource recovery.

4. Kano State Waste Management Agency and licensed private waste-management companies should formalize and strengthen waste-collection arrangements for abattoirs by providing reliable collection schedules, adequate transport equipment, covered containers, and

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designated disposal or treatment facilities. Particular attention should be given to facilities such as Kumbotso, where collection and segregation challenges were more pronounced.

5. Abattoir management committees and butchers' associations should organize regular training for workers on waste segregation, safe handling, temporary storage, occupational hygiene, and environmental protection. Training should be practical and conducted in languages commonly understood by workers, including Hausa.

6. The Kano State Ministry of Health, veterinary public-health authorities, and abattoir health and safety officers should strengthen surveillance of environmental and occupational health risks associated with abattoir waste, particularly exposure to contaminated water, vectors, offensive odours, and potential zoonotic hazards among workers and nearby communities.

7. Abattoir operators, butchers' associations, and private-sector waste-management companies should develop resource-recovery initiatives for animal by-products. Blood, bones, horns, hooves, and paunch contents should be explored for safe conversion into products such as bone meal, compost, and biogas, subject to appropriate health and environmental safeguards.

8. Kano State Government and relevant regulatory agencies should provide financial and technical support for upgrading waste-management facilities, particularly in abattoirs where respondents identified inadequate infrastructure and high operational costs as major barriers to effective waste management.

9. Abattoir management and local government authorities should establish clear accountability for waste management by assigning designated personnel or licensed service providers to oversee collection, segregation, storage, treatment, and final disposal. Performance should be monitored through periodic environmental audits.

10. Future researchers and academic institutions should undertake longitudinal and laboratory-based studies to quantify the microbiological, physicochemical, and chemical characteristics of abattoir waste and effluent, and to assess contamination of receiving water bodies, soil, and groundwater around the major abattoirs of Kano Metropolis. Such studies would provide stronger empirical evidence for risk assessment and intervention planning.

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