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Estimation of Municipal Solid Waste Generation Trends from Selected Dumpsites in Ibadan from 2018–2024

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ABSTRACT

Municipal solid waste (MSW) generation encompasses residential, commercial, institutional, construction, demolition, and sanitation waste streams. This study quantified, characterized, and estimated waste generated at four selected dumpsites in Ibadan, namely Awotan, Lapite, Ajakanga, and Aba Eku, between 2018 and 2024. Annual waste quantities were estimated by projecting Ibadan's population with an exponential growth model and applying a per capita generation rate of 0.55 kg per person per day, after which a 70 percent collection efficiency was used to derive the collected fraction. The collected waste was then distributed across the four sites according to the operative policy allocation ratios for each period, while composition was characterized by applying percentage fractions for each waste category drawn from field and literature sources, and all estimates were validated against Oyo State Waste Management Authority records. On this basis, total waste generated and deposited across all sites was estimated at 10.8 million tonnes, with an average annual input of 1.54 million tonnes. Awotan received the highest annual average (420,000 tonnes), followed by Lapite (380,000 tonnes), Ajakanga (310,000 tonnes), and Aba Eku (210,000 tonnes). Organic matter dominated the waste composition (59%), followed by plastics (10%), paper (9%), textiles (6%), metals (5%), glass (4%), rubber (3%), and others (4%). The 2020 Oyo State waste management policy shift significantly altered the distribution of waste across sites. The Oyo State Government is recommended to institute mandatory waste segregation into organic, recyclable, and inert categories to reduce CO and PM_{10} emissions from open burning.

INTRODUCTION

Municipal solid waste (MSW) generation is rapidly increasing globally, particularly in emerging economies (Shovon *et al.*, 2024). MSW encompasses residential, commercial, institutional, construction, demolition, and sanitation waste. It contains recyclable materials such as paper, plastic, glass, and metals, as well as hazardous substances and compostable organic matter (Ghanbarzadeh *et al.*, 2024). The volume of municipal solid waste (MSW) in developing countries such as Nigeria, India, Bangladesh, Kenya, and Indonesia has increased sharply due to economic growth, urbanization, and rising living standards (Zambrano-Monserrate *et al.*, 2021; Zhang *et al.*, 2024; Alam *et al.*, 2025).

Ibadan, Nigeria's third-largest city, generates approximately three times the MSW it produced in 1981, driven by a 2.6 percent annual population growth rate (Ubanwa *et al.*, 2021; Nwafor, 2024). The quantity and composition of this waste are shaped by income levels, consumption habits, and disposal practices, and they are increasingly influenced by government policy decisions on where and how waste is collected and deposited (Kayode *and* Omole, 2011). In 2020, for example, the Oyo State Government restructured its waste management architecture, a shift that had the potential to alter the distribution of waste across the city's major disposal sites (Vanguard, 2020). Despite the scale of these changes, waste generation in Ibadan has not been systematically quantified across multiple disposal sites or over an extended period, which has constrained evidence-based planning for collection, transportation, and disposal (Akintayo *and* Olonisakin, 2014).

This study, therefore, quantifies, characterizes, and estimates municipal solid waste at four major Ibadan dumpsites, namely Awotan, Lapite, Ajakanga, and Aba Eku, over seven years from 2018 to 2024. It integrates population projection, per capita estimation, and policy-based allocation, with all estimates validated against Oyo State Waste Management Authority records. In doing so, the study provides a multi-site, longitudinal assessment of how the 2020 Oyo State waste management policy reshaped the spatial distribution of waste across the city, while also establishing that waste composition remains largely homogeneous across sites. These outcomes offer data-driven evidence to support government planning and emission-reduction policy.

MATERIALS AND METHODS

Study Area

This study focused on Ibadan, the capital of Oyo State in southwestern Nigeria, specifically targeting four primary waste disposal sites: Ajakanga, Awotan, Lapite, and Aba Eku. Ibadan is Nigeria's third-largest city with a population that grew from approximately 3,565,000 in 2018 to 4,004,000 in 2024. The city covers approximately 3,080 km² and is situated at 7.3775° N, 3.9470° E in a tropical savanna climate zone. Agriculture, trade, and small-scale industries drive its economy, and rapid urbanisation has intensified pressure on waste management infrastructure.

Description of the Study Area

The study focused on four active dumpsites in Ibadan, Oyo State, as shown in Figure 1 . Awotan dumpsite (7.35° N, 3.90° E) emerged as the primary landfill following its 2020 rehabilitation, receiving 30% of collected waste in 2018 (150,230 tonnes) and expanding to 70% by 2024 (450,241 tonnes). Lapite dumpsite (7.38° N, 3.88° E) was the largest site in 2018 (40%; 200,307 tonnes) but declined sharply to 10% by 2024. Ajakanga dumpsite (7.40° N, 3.95° E) and Aba Eku dumpsite each held 15% shares in 2018 (75,115 tonnes each), reducing to 10% after 2020.

All four sites are open, uncontrolled disposal areas where open burning is a widespread practice, particularly during the dry season. Surrounding communities, including Apete and Ojoo, lie within 2–3 km of the sites and are directly exposed to air quality impacts. Organic matter comprising food waste and market refuse constitutes approximately 59% of the waste stream, reflecting Ibadan's active markets such as Oja'ba and Dugbe.

Data Collection

Data on the quantity and composition of collected waste at the four dumpsites were obtained from the Oyo State Waste Management Authority (OYOWMA) annual reports and supplemented with peer-reviewed literature. Population data were sourced from the Nigerian National Bureau of Statistics (NBS, 2019) and the Nigeria Metro Area Population dataset (Macrotrends LLC, 2021), noting values of 3,565,000 in 2018 and 4,004,000 in 2024. Waste distribution ratios across sites for 2018–2019 were guided by Adewole (2018), while the post-2020 distribution was informed by the Oyo State Government (2020) policy directive that restructured waste allocation to prioritize Awotan as the primary landfill.

Population Projection and Waste Quantification

Annual population figures were interpolated using the exponential growth model in Equation 1 (Shabir, 2025):

$$P_{year} = P_{base} \times (1 + r)^n \quad (1)$$

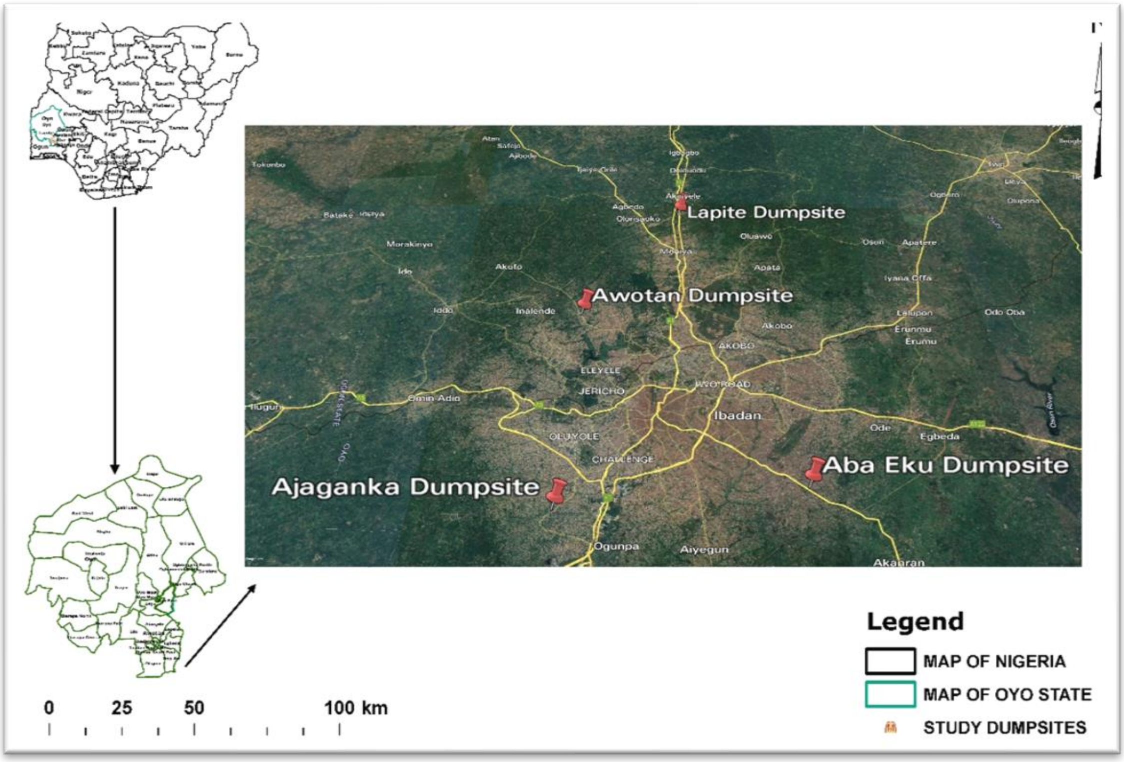

Figure 1: Map showing the study dumpsites (Source: Google Map, 2025)

where P_{base} = 3,565,000, r = 0.026, and n is the year offset from the base year. For example, the 2019 population was estimated as 3,657,490.

Total waste generated was calculated using Equation 2 (Ojo, 2023):

$$W_{total} = \frac{(P_{year} \times 0.55 \times 365)}{1000} \quad (2)$$

where 0.55 kg/day/person is the per capita waste generation rate for Ibadan (Ogundele *et al*., 2018a). This rate was validated against a World Bank (2019) range of 0.50–0.60 kg/day, and 0.55 kg/day was retained as the mean estimate. Collected waste was estimated at 70% of the total generated waste in Equation 3 (Maiha and Yusuf, 2025):

$$W_{collected} = W_{total} \times 0.70 \quad (3)$$

Uncollected waste was derived as:

$$W_{uncollected} = W_{total} - W_{collected} \quad (4)$$

Collection efficiency was assessed using Equation 5 (Yan *et al*., 2020):

$$Collection\ Efficiency\ (\%) = \frac{(W_{collected})}{(W_{Total})} \times 100 \quad (5)$$

Waste Characterization

Waste composition was characterised based on percentage fractions derived from Clement et al. (2025) and Adewole (2018), yielding the following proportions: organic/vegetable matter (59%), plastics (10%), paper (9%), textiles (6%), metals (5%), glass (4%), rubber (3%), and others including dust and ash (4%). These fractions were applied consistently across all four dumpsites and all study years, consistent with the homogeneous waste composition reported for Ibadan by Ogundele et al. (2018a).

RESULT AND DISCUSSION

Population Projection and Waste Generation Totals

Table 1 presents the estimated annual population and corresponding waste volumes for Ibadan from 2018 to 2024. Total waste generated increased from 715,383 tonnes in 2018 to a modelled 804,002 tonnes in 2024, consistent with population growth from 3,565,000 to 4,004,000 persons. Collected waste ranged between 500,768 and 562,801 tonnes annually, reflecting the consistent 70% collection efficiency. Uncollected waste reached 241,201 tonnes in 2024, with significant implications for informal dumping and open burning.

Table 1: Population and municipal solid waste generation in Ibadan (2018–2024)

Year	Population (persons)	Total Waste (tonnes)	Collected Waste (tonnes)	Uncollected Waste (tonnes)
2018	3,565,000	715,383	500,768	214,615
2019	3,657,490	733,480	513,436	220,044
2020	3,751,897	752,431	526,702	225,729
2021	3,848,225	771,237	539,866	231,371
2022	3,946,487	790,904	553,633	237,271
2023	4,046,697	811,436	568,005	243,431
2024	4,004,000	804,002	562,801	241,201

Waste Quantification by Dumpsite

The annual quantity of solid waste received at each dumpsite varied significantly over the study period, reflecting changes in urban population density, consumption patterns, collection efficiency, and Oyo State policy shifts.

Awotan Dumpsite: Waste received increased dramatically from 150,230 tonnes in 2018 to 450,241 tonnes in 2024a 200% increase following its designation as the primary landfill in 2020.

Lapite Dumpsite: Waste received declined from 200,307 tonnes in 2018 to 56,280 tonnes in 2024 as a result of the 2020 policy reallocation.

Ajakanga and Aba Eku Dumpsites: Both sites experienced a notable reduction during the COVID-19 lockdown period (2020-2021), declining to 39,186 tonnes each. Both partially recovered to 56,280 tonnes by 2024.

Waste Characterization

As presented in Figure 2, the four Ibadan dumpsites share identical waste composition, dominated by organic matter at about 59 percent, followed by plastics (10 percent), paper (9 percent), textiles (6 percent), metals (5 percent), glass (4 percent), other materials (4 percent), and rubber (3 percent). The combustible fraction as high as 85 percent, while metals were below 6 percent, indicating little segregation or recycling at source and a pattern typical of Nigerian urban waste. Although composition is uniform, volumes diverge sharply after the 2020 policy reallocation and the pandemic. As shown in Figure 2b, Awotan increased from 150,230 tonnes in 2018 to 450,241 tonnes in 2024, about a 200 percent rise, with organic load peaking near 265,642 tonnes and plastics tripling to roughly 45,024 tonnes. As for Lapite, which is presented in Figure 2c, declined from 200,307 to 56,280 tonnes, while Ajakanga and Aba Eku, presented in Figure 2a and 2d, respectively, were between approximately

39,000 and 76,000 tonnes, dipping during the 2020 to 2021 lockdown. The dominance of organic waste drives methane and biogenic carbon dioxide emissions, whereas open burning of plastics, rubber, and textiles releases carbon monoxide, oxides of nitrogen, volatile organic compounds, particulate matter, polycyclic aromatic hydrocarbons, hydrogen chloride, dioxins, furans, and heavy metals (Preble *et al*., 2020). The rise of plastic waste was a pointer to a growing microplastic pollution risk. The concentration of waste at Awotan intensifies the burden on nearby communities and strengthens the case for source segregation, controlled disposal, and waste-to-energy recovery.

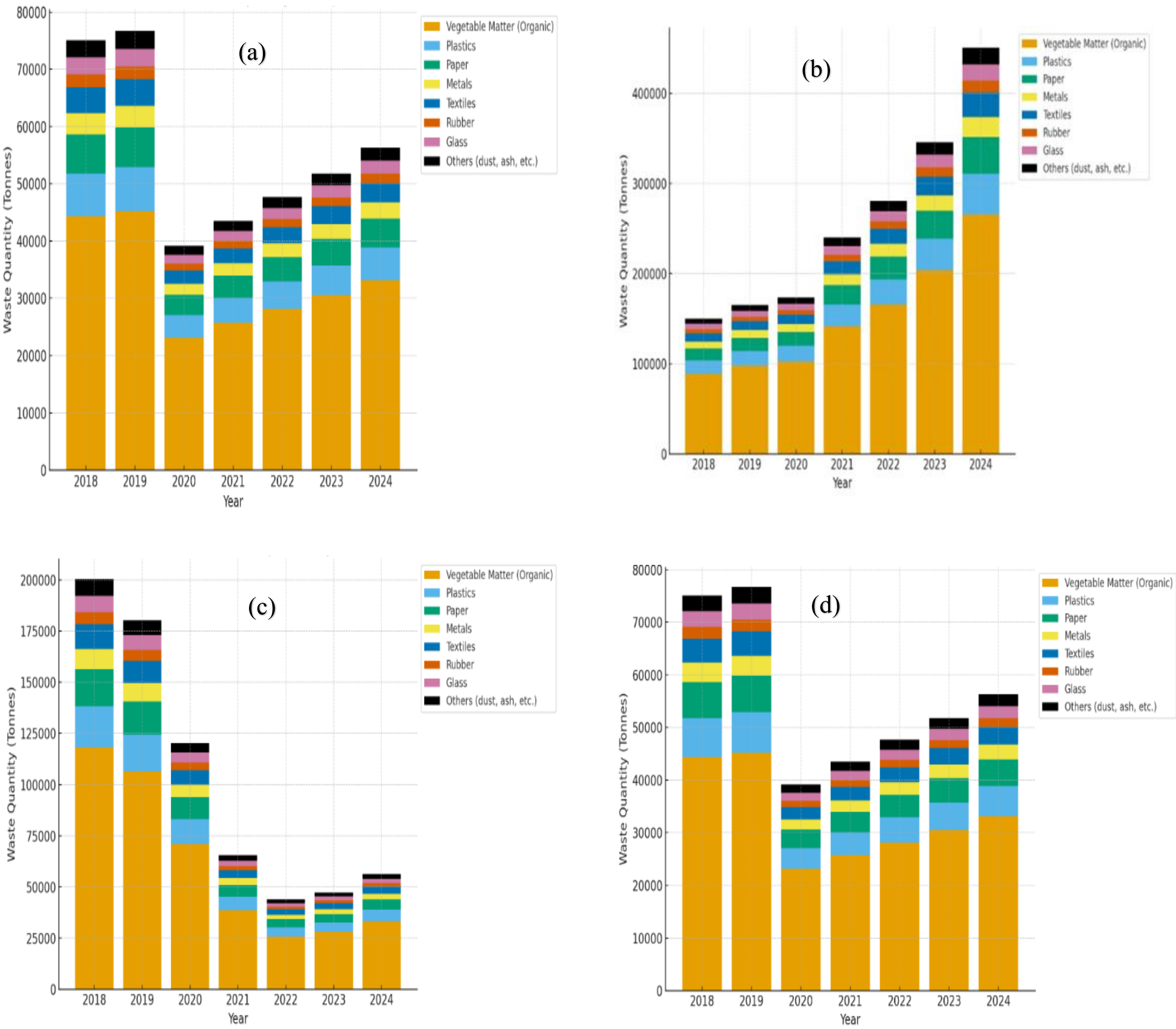

Figure 2: Characterized municipal solid waste in 2018-2024 for dumpsites in (a) Ajakanga, (b)Awotan, (c) Lapite, (d) Aba-Eku

Table 2 presents detailed waste type estimations by site and year. The composition profile across sites indicates a characteristic pattern of urban MSW in Nigeria, which is characterised by abundant organic and plastic waste without meaningful source segregation. The estimated annual mass of each waste category across the four dumpsites for 2018 to 2024, with composition fixed at 59% organic, 10% plastics, 9% paper, 6% textiles, 5% metals, 4% glass, 4% others, and 3% rubber for all sites and years. The principal trend is the post-2020 divergence in site totals driven by the policy reallocation:

Table 2: Estimated municipal solid waste and waste type for Ajakanga dumpsite (selected years). Combined Table: Estimated municipal solid waste by type for Ajakanga, Awotan, Lapite, and Abaeku dumpsites (2018-2024)

Year	Waste Type	%	Ajakanga	Awotan	Lapite	Abaeku
2018	Organic	59	44,318.85	88,635.70	118,181.13	44,318.85
2018	Plastics	10	7,511.50	15,023.00	20,030.70	7,511.50
2018	Paper	9	6,760.35	13,520.70	18,027.63	6,760.35
2018	Metals	5	3,755.75	7,511.50	10,015.35	3,755.75
2018	Textiles	6	4,506.90	9,013.80	12,018.42	4,506.90
2018	Rubber	3	2,253.45	4,506.90	6,009.21	2,253.45
2018	Glass	4	3,004.60	6,009.20	8,012.28	3,004.60
2018	Others	4	3,004.60	6,009.20	8,012.28	3,004.60
2018	**Total**	**100**	**75,115**	**150,230**	**200,307**	**75,115**
2019	Organic	59	45,225.27	90,451.13	120,601.31	45,225.27
2019	Plastics	10	7,665.30	15,330.70	20,440.90	7,665.30
2019	Paper	9	6,898.77	13,797.63	18,396.81	6,898.77
2019	Metals	5	3,832.65	7,665.35	10,220.45	3,832.65
2019	Textiles	6	4,599.18	9,198.42	12,264.54	4,599.18
2019	Rubber	3	2,299.59	4,599.21	6,009.21	2,299.59
2019	Glass	4	3,066.12	6,132.28	8,012.28	3,066.12
2019	Others	4	3,066.12	6,132.28	8,012.28	3,066.12
2019	**Total**	**100**	**76,653**	**153,307**	**204,409**	**76,653**
2020	Organic	59	23,119.74	161,836.41	23,119.74	23,119.74
2020	Plastics	10	3,918.60	27,429.90	3,918.60	3,918.60
2020	Paper	9	3,526.74	24,686.91	3,526.74	3,526.74
2020	Metals	5	1,959.30	13,714.95	1,959.30	1,959.30
2020	Textiles	6	2,351.16	16,457.94	2,351.16	2,351.16
2020	Rubber	3	1,175.58	8,228.97	1,175.58	1,175.58
2020	Glass	4	1,567.44	10,971.96	1,567.44	1,567.44
2020	Others	4	1,567.44	10,971.96	1,567.44	1,567.44
2020	**Total**	**100**	**39,186**	**274,299**	**39,186**	**39,186**
2021	Organic	59	23,557.52	164,902.64	23,557.52	23,557.52
2021	Plastics	10	3,992.80	27,949.60	3,992.80	3,992.80
2021	Paper	9	3,593.52	25,154.64	3,593.52	3,593.52
2021	Metals	5	1,996.40	13,974.80	1,996.40	1,996.40
2021	Textiles	6	2,395.68	16,769.76	2,395.68	2,395.68
2021	Rubber	3	1,197.84	8,384.88	1,197.84	1,197.84
2021	Glass	4	1,597.12	11,179.84	1,597.12	1,597.12
2021	Others	4	1,597.12	11,179.84	1,597.12	1,597.12
2021	**Total**	**100**	**39,928**	**279,496**	**39,928**	**39,928**
2022	Organic	59	24,003.97	168,021.97	24,003.97	24,003.97
2022	Plastics	10	4,068.30	28,478.30	4,068.30	4,068.30
2022	Paper	9	3,661.47	25,630.47	3,661.47	3,661.47
2022	Metals	5	2,034.15	14,239.15	2,034.15	2,034.15
2022	Textiles	6	2,440.98	17,086.98	2,440.98	2,440.98
2022	Rubber	3	1,220.49	8,543.49	1,220.49	1,220.49
2022	Glass	4	1,627.32	11,391.32	1,627.32	1,627.32
2022	Others	4	1,627.32	11,391.32	1,627.32	1,627.32
2022	**Total**	**100**	**40,683**	**284,783**	**40,683**	**40,683**
2023	Organic	59	24,457.86	171,206.79	24,457.86	24,457.86
2023	Plastics	10	4,145.40	29,018.10	4,145.40	4,145.40
2023	Paper	9	3,730.86	26,116.29	3,730.86	3,730.86
2023	Metals	5	2,072.70	14,509.05	2,072.70	2,072.70
2023	Textiles	6	2,487.24	17,410.86	2,487.24	2,487.24
2023	Rubber	3	1,243.62	8,705.43	1,243.62	1,243.62
2023	Glass	4	1,658.16	11,607.24	1,658.16	1,658.16
2023	Others	4	1,658.16	11,607.24	1,658.16	1,658.16
2023	**Total**	**100**	**41,454**	**290,181**	**41,454**	**41,454**
2024	Organic	59	33,205.20	265,642.19	33,205.20	33,205.20
2024	Plastics	10	5,628.00	45,024.10	5,628.00	5,628.00
2024	Paper	9	5,065.20	40,521.69	5,065.20	5,065.20

2024	Metals	5	2,814.00	22,512.05	2,814.00	2,814.00
2024	Textiles	6	3,376.80	27,014.46	3,376.80	3,376.80
2024	Rubber	3	1,688.40	13,507.23	1,688.40	1,688.40
2024	Glass	4	2,251.20	18,009.64	2,251.20	2,251.20
2024	Others	4	2,251.20	18,009.64	2,251.20	2,251.20
2024	**Total**	**100**	**56,280**	**450,241**	**56,280**	**56,280**

Awotan increases from 150,230 (2018) to 450,241 (2024), raising its organic fraction to 265,642 and its plastics to 45,024, whereas Lapite declines from 200,307 t to 56,280 over the same interval. Ajakanga and Aba Eku exhibit near-identical trajectories, contracting to 39,186 each during the 2020 to 2021 period before recovering to 56,280 by 2024. Because the percentage distribution is held constant, each waste-type mass scales linearly with the site total, so the table indicates variation in throughput and allocation rather than compositional change. The combustible fraction remains at approximately 85% throughout, indicating a sustained open-burning emission potential that becomes concentrated at Awotan.

Implications for Air Quality and Waste Management

The dominance of organic matter (59%) in all sites implies that biodegradation and anaerobic decomposition are primary drivers of CH_4 and biogenic CO_2 emissions. The significant plastic (10%) and rubber (3%) fractions indicate a high potential for dioxin, furan, PAH, and HCl emissions during open burning events, which are frequent at all four sites, particularly during the dry season. The rapid increase in waste volumes at Awotan from 150,230 tonnes (2018) to 450,241 tonnes (2024) heightens the environmental burden on surrounding residential communities within 2–3 km of the site.

The consistent 30% uncollected waste fraction across all years (ranging from 214,615 to 241,201 tonnes annually) represents a persistent challenge for informal open burning and illegal dumping. Cross-site comparison confirms that Ibadan's waste is largely homogeneous in composition, suggesting that citywide waste segregation policies would have broad applicability and impact.

CONCLUSION

This study quantified, characterised, and estimated municipal solid waste generation at four major dumpsites in Ibadan: Awotan, Lapite, Ajakanga, and Aba Eku between 2018 and 2024, yielding the following specific findings:

(i) Total waste generation: The four dumpsites collectively received an estimated 10.8 million tonnes over the study period, averaging 1.54 million tonnes annually. Annual generation increased from 715,383 tonnes in 2018 to a peak modelled estimate of 804,002 tonnes in 2024, driven by Ibadan population growth from 3,565,000 to 4,004,000 persons within this study period.

(ii) Dumpsite-level trends: Awotan emerged as the major collection dumpsite, receiving an average of 420,000 tonnes annually and recording a 200% increase in waste intake between 2018 and 2024 following the 2020 Oyo State waste management policy restructuring. Lapite declined from 200,307 tonnes (2018) to 56,280 tonnes (2024), while Ajakanga and Aba Eku each declined from 75,115 tonnes (2018) to 56,280 tonnes (2024) due to reduced allocations and COVID-19 operational disruptions.

(iii) Waste composition: Organic matter constituted 59% of total waste at all sites, followed by plastics (10%), paper (9%), textiles (6%), metals (5%), glass (4%), rubber (3%), and others (4%). The high combustible fraction (~85%) represents a significant driver of PM_{10}, CO, and toxic organic emissions from open burning.

(iv) Policy recommendation: The Oyo State Government should urgently institute mandatory waste segregation at source, separating organic, recyclable, and inert fractions across Ibadan's collection network. This measure would directly reduce the volume of plastics, textiles, and combustible materials reaching open dumpsites, thereby decreasing emissions of CO, PM_{10}, and dioxins. Additionally, waste-to-energy technologies and controlled disposal practices should be prioritised at Awotan given its scale of operation.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with this article.

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