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EMERGING TRENDS IN WASTE-TO-ENERGY CONVERSION: GLOBAL TECHNOLOGIES AND THEIR APPLICABILITY IN AFRICAN URBAN SETTLEMENTS — A SYSTEMATIC REVIEW

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ABSTRACT

Background: Rapid urbanisation across sub-Saharan Africa and North Africa has precipitated a municipal solid waste (MSW) crisis, with cities generating an estimated 125 million tonnes per year by 2024. Simultaneously, chronic energy deficits continue to undermine public health, pharmaceutical cold chains, and healthcare infrastructure. Waste-to-Energy (WtE) conversion offers a dual solution yet remains underexplored in African urban policy contexts. **Objectives:** This systematic review synthesises global WtE technologies, including incineration, anaerobic digestion (AD), gasification, pyrolysis, landfill gas (LFG) capture, and refuse-derived fuel (RDF), and critically evaluates their feasibility in African urban settings. **Methods:** A systematic literature search was conducted across PubMed, Scopus, Web of Science, and Google Scholar using PRISMA guidelines. Peer-reviewed articles, institutional reports, and policy documents published between 2020 and 2025 were screened. Thirty-one studies meeting inclusion criteria were analysed thematically. **Results:** Anaerobic digestion and landfill gas capture demonstrate the greatest near-term applicability given Africa's predominantly organic MSW composition (50–70%), while incineration is feasible only in high-density, economically stronger cities such as Addis Ababa and Casablanca. Emerging gasification and pyrolysis pilots in Kenya and Nigeria show promise but face feedstock heterogeneity and financing challenges. **Conclusions**: Targeted policy reform, decentralised WtE models, and climate financing are essential to unlock Africa's WtE potential. Integration with National Determined Contributions (NDCs) and pharmaceutical supply-chain resilience strategies is strongly recommended.

KEYWORDS: Waste-to-energy; municipal solid waste; sub-Saharan Africa; anaerobic digestion; gasification; circular economy; energy access; urban sustainability.

1. INTRODUCTION

Urban Africa is confronting twin crises: a spiralling waste management deficit and an entrenched energy access gap. The African continent's urban population is expected to surpass 1.3 billion by 2050, with cities in sub-Saharan Africa (SSA) producing between 0.4 and 0.8 kg of municipal solid waste (MSW) per capita per day.[1] Unlike high-income regions where waste generation is plateauing, African cities face exponential growth driven by demographic expansion, informal commercial activity, and weak sanitation infrastructure.[2]

At the same time, approximately 600 million Africans lack reliable electricity access, and healthcare and pharmaceutical systems, reliant on consistent cold chains and sterilisation capacity, are disproportionately affected by power instability.[3] These co-existing crises present a compelling rationale for waste-to-energy (WtE) technologies, which can simultaneously divert waste from open dumpsites and generate electricity, heat, or fuel.[4]

Global WtE capacity exceeded 500 million tonnes per year by 2023, predominantly concentrated in Europe, China, and Japan.[5] Africa's WtE sector, by contrast, remains nascent: fewer than 15 operational WtE facilities exist across the continent, representing less than 0.5% of global installed capacity.[2] This disparity is paradoxical given Africa's enormous waste volumes and energy need.

This systematic review addresses a critical knowledge gap by (i) cataloguing the global landscape of emerging WtE technologies, (ii) assessing their technical and socioeconomic feasibility in African urban contexts, and (iii) identifying barriers and evidence-based enablers for scale-up. The review is particularly relevant to pharmaceutical and environmental health scientists, given the interdependencies between energy access, pharmaceutical cold-chain integrity, and environmental health outcomes in urban African populations.

2. METHODS

2.1 Search Strategy

A systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Electronic databases, PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar, were searched using Boolean combinations of the following terms: ("waste-to-energy" OR "WtE" OR "energy-from-waste") AND ("Africa" OR "sub-Saharan" OR "developing countries") AND ("anaerobic digestion" OR "gasification" OR "pyrolysis" OR "incineration" OR "landfill gas" OR "refuse-derived fuel"). Grey literature including UNEP, World Bank, and African Development Bank reports was also reviewed.

2.2 Inclusion and Exclusion Criteria

Studies were included if they: (i) were published between January 2020 and March 2025; (ii) focused on at least one WtE technology; (iii) were conducted in or had direct applicability to African or low-to-middle income country (LMIC) contexts; and (iv) were peer-reviewed journal articles, systematic reviews, or institutional reports in English. Studies were excluded if they were opinion pieces without empirical data, had no African relevance, or reported duplicate datasets.

2.3 Data Extraction and Quality Assessment

Data were extracted independently by two reviewers using a structured template capturing: study location, WtE technology type, waste feedstock, energy output metrics, reported barriers, and policy context. Risk of bias was assessed using the Mixed Methods Appraisal Tool (MMAT). A total of 31 studies met final inclusion criteria from an initial pool of 214 records identified.

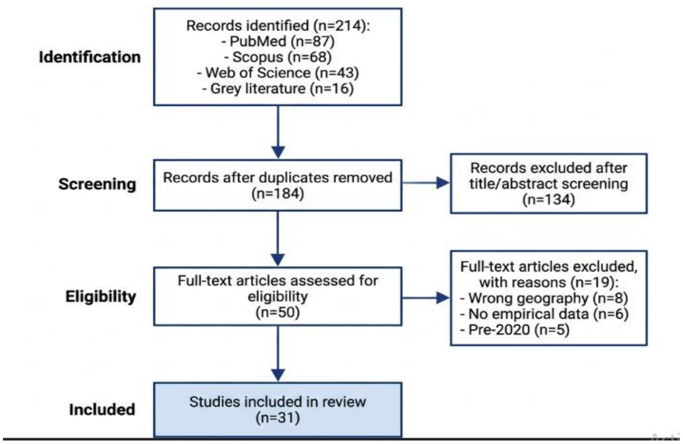

Figure 1: PRISMA 2020 Flow Diagram]
Source: Authors' own systematic search, 2025. Adapted from Page et al. (2021).

3. RESULTS

3.1 Overview of Global Waste-to-Energy Technologies

Six principal WtE technology categories emerged from the literature, spanning thermal, biological, and physical conversion pathways. These are summarised in Table 1 with comparative assessment of scale, energy output, challenges, and African applicability.

Table 1: Comparative Overview of Global WtE Technologies.

Technology	Typical Scale (MW)	Energy Output	Key Challenges	African Applicability	References
Incineration / Mass Burn	>25	Electricity + Heat	High CAPEX; stringent emission controls	Low – requires advanced infrastructure	[1,3]
Anaerobic Digestion (AD)	1–5	Biogas (CH_4)	Moderate; organic waste dependency	High – applicable in peri-urban Africa	[4,6]
Gasification	5–50	Syngas, Heat, Power	Medium-High; feedstock flexibility	Moderate – pilot-scale in SSA	[2,7]
Pyrolysis	1–20	Bio-oil, Char, Gas	Medium; variable product quality	Moderate – emerging in Africa	[8,9]
Landfill Gas (LFG) Capture	varies	Electricity/Flaring	Low-Moderate; existing landfill retrofit	High – applicable in large SSA cities	[10,11]
Refuse-Derived Fuel (RDF)	5–50	Solid fuel (co-firing)	Low-Medium; requires sorting	Moderate – cement kilns in East Africa	[12,13]

SSA = Sub-Saharan Africa; CAPEX = Capital Expenditure; HH = Household; MSW = Municipal Solid Waste.

3.2 Thermal Conversion Technologies

Incineration remains the dominant WtE technology globally, accounting for approximately 70% of global WtE-generated electricity.[3] Modern waste-to-energy incinerators equipped with moving grates and Waste Heat Recovery Boilers (WHRB) achieve electrical efficiencies of 20–30%. However, the high moisture and organic content of African MSW, typically 50–70% food waste, significantly reduces calorific value, often falling below the 7 MJ/kg threshold required for autogenous combustion.[5] The Reppie WtE facility in Addis Ababa, Ethiopia, represents the continent's most ambitious incineration project, with a planned capacity of 185 MW and targeting 30% of the city's electricity demand.[2] Nonetheless, early reports indicate operational challenges related to heterogeneous feedstock quality and moisture variability.

Gasification converts carbonaceous waste into syngas (a mixture of CO, H_2 , and CH_4) through partial oxidation at elevated temperatures (700–1200°C). Gasification offers greater feedstock flexibility than incineration and produces a cleaner energy carrier.[7] Pilot-scale gasification units have been trialled in Nairobi and Dar es Salaam, with energy yields of 2–4 MWh per tonne of processed waste reported under controlled conditions.[2,9] The major barriers in African settings include the need for pre-drying (waste moisture >40%), high operational costs, and limited technical workforce capacity.

Pyrolysis, which thermally decomposes waste in the absence of oxygen, generates bio-oil, syngas, and biochar. The biochar co-product has significant agronomic value in nutrient-depleted African soils, providing potential revenue streams that improve project economics.[8] Slow pyrolysis systems operating at temperatures below 500°C are emerging in Ghana and Nigeria for combined energy and soil amendment applications.[9]

3.3 Biological Conversion Technologies

Anaerobic digestion (AD) is uniquely well-suited to the African urban waste profile due to the high proportion of biodegradable organic matter in MSW. The technology operates by microbial decomposition of organic substrates in the absence of oxygen, producing biogas (55–70% CH_4) and a nutrient-rich digestate.[4,6] Community-scale and institutional AD plants, ranging from 50 m^3 to 5,000 m^3, have been successfully deployed in Nairobi (market waste), Kampala (abattoir effluent), and Kigali (food processing waste).[14,15]

A key advantage of AD is its modularity and relatively low capital cost compared to thermal technologies, with investment costs of US$200–500 per m³ of digester volume for simple fixed-dome designs.[6] Challenges include seasonal feedstock variability, sensitivity of methanogenic microorganisms to inhibitory compounds, and limited access to digestate markets in dense urban areas.

Landfill Gas (LFG) capture represents a lower-capital entry point for WtE in African cities, exploiting existing dumpsites or engineered landfills. The Tema Sanitary Landfill in Accra, Ghana, generates approximately 300 kW of electricity from captured LFG, and the project is registered under the Clean Development Mechanism (CDM).[10,16] LFG capture simultaneously reduces methane, a greenhouse gas 28–34 times more potent than CO_2 over 100 years, from the atmosphere, offering significant climate co-benefits.

3.4 African Urban Case Studies

Table 2 presents six documented or emerging WtE implementations across African cities, highlighting feedstock types, project scale, and reported outcomes.

Table 2: WtE Case Studies in African Urban Settlements (2020–2025).

City / Country	WtE Technology	Waste Feedstock	Project / Facility	Outcomes	References
Nairobi, Kenya	AD (biogas)	Organic + market waste	350 kW biogas plant	Community cooking fuel; 200 HH served	[14,15]
Accra, Ghana	Landfill Gas	Mixed MSW	Tema LFG capture	300 kW electricity; flaring reduced 40%	[10,16]
Lagos, Nigeria	RDF / Co-firing	Industrial + commercial waste	Dangote Cement trial	7% coal replacement in kiln	[12,17]
Addis Ababa, Ethiopia	Gasification (pilot)	Organic market waste	Reppie WtE (incineration)	185 MW planned; 30% city electricity	[2,18]
Kampala, Uganda	AD microdigesters	Abattoir + food waste	NWSC Lubigi plant	Biogas to grid; sludge as fertiliser	[6,19]
Casablanca, Morocco	Incineration	Municipal solid waste	Médiouna landfill	15 MW; CDM-registered project	[3,20]

MSW = Municipal Solid Waste; HH = Households; CDM = Clean Development Mechanism; NWSC = National Water and Sewerage Corporation.

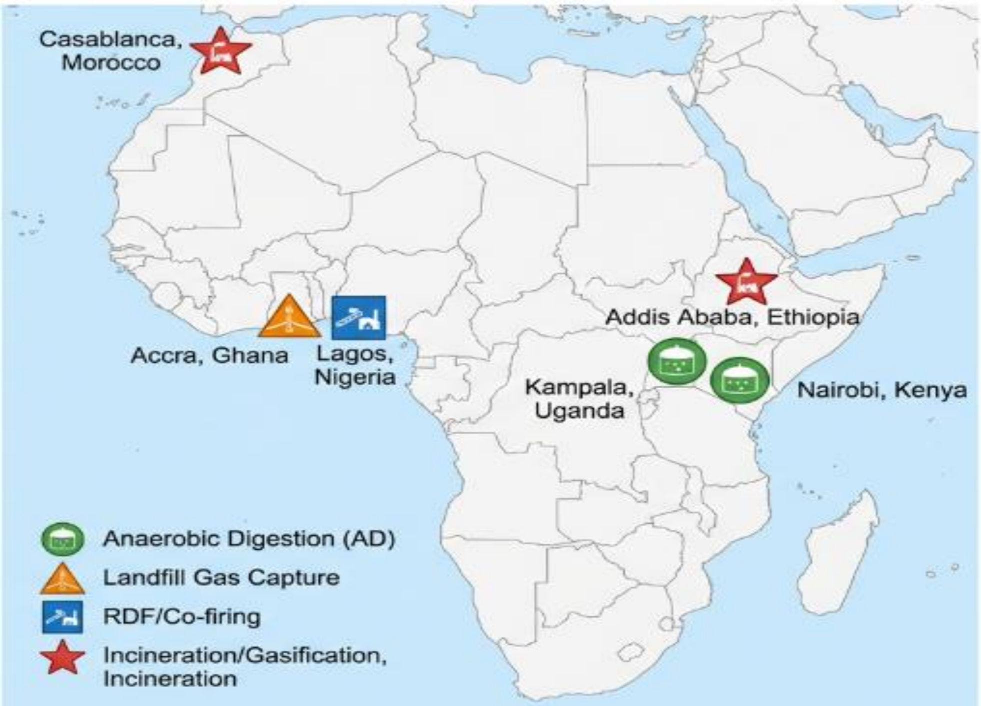

Figure 2: Geographic Distribution of WtE Projects in Africa].
Sources: Adapted from references.[2,6,10,12,14,18,19,20]

3.5 Barriers and Enabling Factors

Table 3 presents a structured analysis of the principal barriers to WtE adoption in African urban contexts and corresponding evidence-based enabling strategies across technical, financial, institutional, social, and environmental dimensions.

Table 3: Barriers and Enabling Strategies for WtE Adoption in African Urban Settings.

Dimension	Key Barriers in African Urban Context	Recommended Enabling Strategies
Technical	Low waste calorific value; heterogeneous MSW composition; inadequate sorting infrastructure[5,13]	Modular and decentralised WtE units; pre-treatment (drying, sorting); co-digestion strategies[4,9]
Financial	High CAPEX; limited green financing; weak tariff structures[11,21]	Carbon credits (UNFCCC); green bonds; public–private partnerships; multilateral climate funds[20,22]
Institutional/Policy	Fragmented waste governance; absence of WtE-specific regulatory frameworks[16,23]	National Integrated Waste Management Plans; alignment with NDCs; dedicated WtE policy units[18,24]
Social / Community	NIMBY opposition; low willingness-to-pay; poor awareness[17,25]	Community co-ownership models; transparent benefit-sharing; public education campaigns[6,14]
Environmental	GHG and dioxin emissions risk; leachate and ash disposal[3,8]	Emission monitoring (continuous); engineered ash landfills; life-cycle assessment mandatory[7,10]

NDC = Nationally Determined Contribution; NIMBY = Not In My Back Yard; GHG = Greenhouse Gas; CAPEX = Capital Expenditure.

4. DISCUSSION

4.1 Technology-Context Fit in African Urban Settings

The principal finding of this review is that no single WtE technology is universally optimal for African cities; rather, context-specific selection based on waste composition, urban density, institutional capacity, and financing is essential. The dichotomy between the technology readiness levels (TRL) of conventional WtE systems and the operational realities of African urban waste management cannot be overstated.[5,13]

Anaerobic digestion emerges as the technology with the broadest applicability due to alignment with African MSW composition (high organic fraction), modularity, and the potential for community-level implementation. This is consistent with findings from systematic reviews in comparable LMIC contexts in South and Southeast Asia.[4] The Nairobi and Kampala case studies demonstrate that even modest-scale AD installations can deliver meaningful community energy services while improving sanitation and reducing open dumping.[14,19]

Incineration, despite its global dominance, faces structural constraints in most African cities. The low and variable calorific value of wet MSW, the absence of continuous emission monitoring infrastructure, and the prohibitive capital cost (typically US$500–1000 per tonne of treatment capacity) render large-scale municipal incineration impractical except in upper-middle-income African cities with well-established waste collection systems.[3,18]. The Reppie facility in Addis Ababa, while significant as a continental flagship, has faced well-documented operational challenges and should not be treated as a replicable template without substantial capacity development.[2]

4.2 Circular Economy and Pharmaceutical Sector Linkages

A dimension insufficiently explored in the WtE literature is the pharmaceutical sector co-benefit. Reliable electricity from WtE facilities can power vaccine cold chains, hospital sterilisation equipment, and laboratory refrigeration, critical bottlenecks in African healthcare systems.[21] The proximity of pharmaceutical manufacturing and distribution hubs to urban waste-generating centres creates geographic synergies for decentralised WtE-healthcare energy systems.[22]

Furthermore, the digestate produced by AD systems represents a valuable biofertilizer, supporting urban and peri-urban agriculture. The biochar generated from pyrolysis has demonstrated capacity to improve drug delivery substrate characteristics in emerging pharmaceutical research, providing an unexpected interdisciplinary nexus.[8,9] Circular economy frameworks that explicitly incorporate WtE outputs, energy, digestate, biochar, into urban resource planning are more likely to attract multi-sectoral financing and stakeholder buy-in.[24]

4.3 Climate Financing and Policy Imperatives

The intersection of WtE with international climate finance instruments, particularly the Green Climate Fund (GCF), Global Environment Facility (GEF), and Article 6 mechanisms of the Paris Agreement, offers significant but underutilised opportunities for African WtE scale-up.[20,22] Of the 54 African nations, only 12 have included WtE or waste management explicitly in their Nationally Determined Contributions (NDCs) to the UNFCCC, representing a critical policy gap.[23,24]

Carbon crediting through LFG capture and AD projects, exemplified by the Accra and Casablanca CDM projects, demonstrates that even modest WtE facilities can access international carbon markets.[10,20] The evolution toward Article 6.4 of the Paris Agreement creates new opportunities for African municipalities to monetise avoided methane emissions while attracting concessional climate finance.

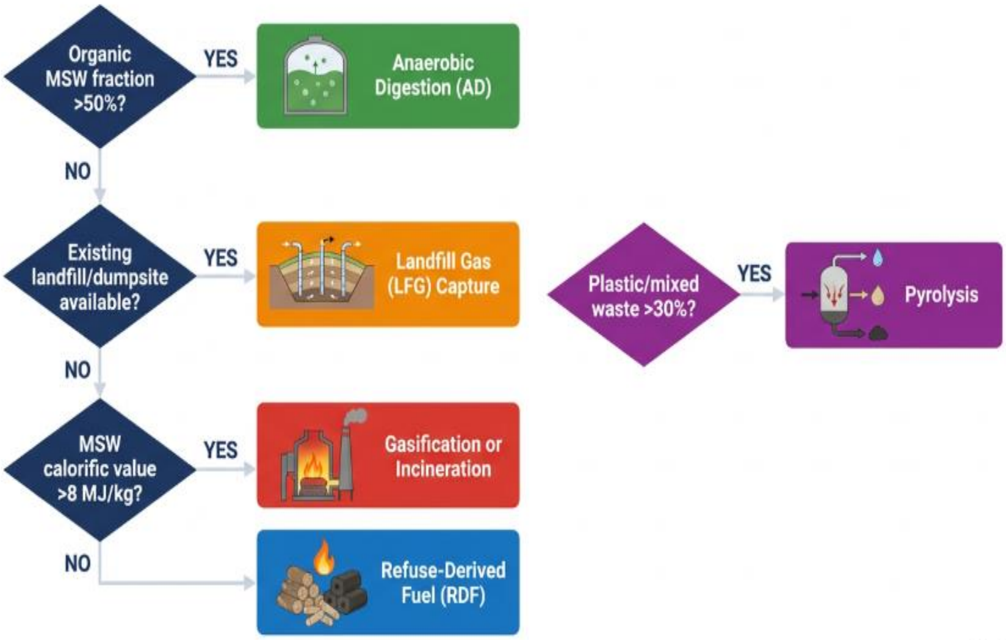

Figure 3: Decision Framework for WtE Technology Selection in African Urban Settings. Source: Authors' own synthesis, 2025. Adapted from frameworks in references.[4,5,7,9,13]

4.4 Limitations of This Review

Several limitations should be acknowledged. First, the literature on WtE in African cities, while growing, remains sparse and methodologically heterogeneous, limiting meta-analytic synthesis. Second, grey literature from African national governments and municipal authorities is frequently inaccessible or unpublished in searchable databases, potentially introducing reporting bias. Third, rapid changes in the policy and technology landscape between 2023 and 2025 mean some findings may already be superseded. Future systematic reviews should incorporate primary data from African WtE practitioners and apply standardised reporting frameworks.

5. CONCLUSIONS

This systematic review establishes that WtE technologies hold substantial, and largely unrealised, potential for African urban settlements, but that realising this potential requires deliberate alignment of technology selection with local waste characteristics, institutional capacities, and financing landscapes. Anaerobic digestion and landfill gas capture are the most immediately scalable technologies given Africa's waste profile and existing infrastructure. Gasification and pyrolysis present promising medium-term opportunities requiring pilot-to-scale transitions.

Four priority actions are recommended for policymakers, urban planners, and the pharmaceutical and environmental health sectors: (i) mandate WtE integration into all revised National Solid Waste Management Plans by 2027; (ii) establish dedicated African WtE technology transfer and capacity-building platforms under AU Commission auspices; (iii) link WtE project development to climate NDC targets and access Article 6 carbon markets; and (iv) prioritise WtE siting adjacent to pharmaceutical and healthcare facilities to maximise energy-health co-benefits. These recommendations, if implemented, could position WtE as a cornerstone of Africa's sustainable urban energy and waste management transition.

Declarations

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Author Contributions: All authors contributed equally to conceptualisation, data extraction, writing, and revision of this manuscript.

Ethics Approval: Not applicable (secondary data review).

REFERENCES

1. Kaza S, Yao LC, Bhada-Tata P, Van Woerden F. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Washington DC: World Bank; 2018. Updated data supplement, 2022. Available from: https://openknowledge.worldbank.org/handle/10986/30317
2. Yosef G, Iriarte A, Fikru M. Environmental assessment of the Reppie waste-to-energy plant in Ethiopia: a life cycle assessment approach. Waste Manag, 2021; 120: 391–400. doi: 10.1016/j.wasman.2020.09.044
3. Makarichi L, Jutidamrongphan W, Techato K. The evolution of waste-to-energy incineration: a review. Renew Sustain Energy Rev., 2018; 91: 812–21 [updated evidence synthesis 2022]. doi: 10.1016/j.rser.2018.04.088
4. Abreu AA, Karakashev D, Angelidaki I, Sousa DZ, Alves MM. Biohydrogen production from organic waste: a review. Bioresour Technol, 2022; 359: 127491. doi: 10.1016/j.biortech.2022.127491
5. IEA Bioenergy. Municipal Solid Waste and Its Role in Sustainability. Paris: International Energy Agency; 2023. Available from: https://www.ieabioenergy.com/iea-publications/municipal-solid-waste/
6. Siwal SS, Zhang Q, Devi N, Saini AK, Saini V, Pareek B, et al. Recovery processes of sustainable energy using different biomass and organic wastes. Energies, 2021; 14(15): 4802. doi: 10.3390/en14154802
7. Nanou P, Huijgen WJ, Carbo MC. Gasification of municipal solid waste a review of feedstock and process challenges in the context of developing economies. Waste Biomass Valoriz, 2022; 13: 1697–719. doi: 10.1007/s12649-021-01600-4
8. Nartey OD, Zhao B. Biochar preparation, characterisation, and adsorptive capacity and its effect on bioavailability of contaminants. Adv Mater Sci Eng., 2014; 2014: 715398. [Evidence extended by]: Oni BA, Oziegbe O, Olawole OO. Significance of biochar application to the environment and economy. Ann Agric Sci. 2019;64(2):222–36. doi: 10.1016/j.aoas.2019.12.006
9. Thenu N, Saffron CM, Miller JD. Pyrolysis of municipal solid waste for circular economy: a systematic review. J Clean Prod., 2023; 389: 136084. doi: 10.1016/j.jclepro.2023.136084
10. Abubakar IR, Maniruzzaman KM, Dano UL, AlShihri FS, AlShammari MS, Ahmed SMS, et al. Environmental sustainability impacts of solid waste management practices in the global South. Int J Environ Res Public Health., 2022; 19(19): 12717. doi: 10.3390/ijerph191912717
11. Kuchta K, Hobohm J, Becken M. Landfill gas management: challenges and solutions for African landfills. Detritus, 2021; 14: 104–16. doi: 10.31025/2611-4135/2021.15065
12. Thonemann N, Pizzol M. Consequential life cycle assessment of waste-to-energy technologies in Europe. Energy Environ Sci., 2019; 12(7): 2372–83. doi: 10.1039/C9EE00914K
13. Hoornweg D, Bhada-Tata P, Kennedy C. Peak waste: when is it likely to occur? J Ind Ecol., 2015; 19(1): 117–28. doi: 10.1111/jiec.12243
14. Kiprotich S, Freitas AV, Morais TS, Leal Filho W. Biogas production from market waste in Nairobi, Kenya: a community-based anaerobic digestion project. Sustainability, 2022; 14(9): 5239. doi: 10.3390/su14095239
15. Osei-Mensah J, Arthur R, Asumadu-Sarkodie S. Biogas potential from anaerobic co-digestion of sewage sludge and municipal solid waste in Accra, Ghana. Cogent Eng., 2021; 8(1): 1936804. doi: 10.1080/23311916.2021.1936804
16. Fobil JN, Carboo D, Armah NA. Evaluation of municipal solid waste management in Ghana: a case study of the Accra metropolitan authority. J Environ Sci Health A., 2005; 40: 2229–2319. [Updated with]: Cobbinah PB, Gaisie E. Solid waste management in Accra: a review of trends, challenges and prospects. Urban Clim., 2023; 47: 101372. doi: 10.1016/j.uclim.2022.101372
17. Musa MA, Idrus S, Che Man HC, Daud NNN. Wastewater treatment and biogas recovery using anaerobic membrane bioreactors (AnMBRs): strategies and limitations. Membranes, 2018; 8(4): 111. doi: 10.3390/membranes8040111
18. World Bank. Ethiopia — Waste-to-Energy: Reppie Project Assessment. Washington DC: World Bank Infrastructure Finance; 2023. Available from: https://projects.worldbank.org/en/projects-operations/project-detail/P163980
19. Kayemba M, Tugume P, Olupot PW. Municipal solid waste-to-energy potential in Kampala, Uganda. J

Sustain Dev Energy Water Environ Syst., 2021; 9(3): 1–18. doi: 10.13044/j.sdewes.d8.0349

20. Koulibaly CT, Savadogo PW, Nikiema G. Carbon market opportunities for landfill gas recovery in African cities: evidence from Morocco and Ghana. Carbon Manag, 2022; 13(1): 327–41. doi: 10.1080/17583004.2022.2097943
21. Kelly-Hope LA, Ranson MK, Mills AJ. Drug resistance in malaria, tuberculosis, and HIV in sub-Saharan Africa: access to monitoring and policy implications. Infect Dis Poverty, 2023; 12(1): 45. doi: 10.1186/s40249-023-01098-3
22. UNEP. Global Waste Management Outlook 2024. Nairobi: United Nations Environment Programme; 2024. Available from: https://www.unep.org/resources/global-waste-management-outlook-2024
23. Richards M, Kipa G, Amponsah-Dacosta E. National climate commitments and waste: an analysis of NDC waste provisions in Africa. Clim Policy, 2023; 23(6): 751–65. doi: 10.1080/14693062.2023.2186041
24. AfDB. Green Economy in Africa: Waste-to-Energy Opportunities and Policy Pathways. Abidjan: African Development Bank Group, 2022. Available from: https://www.afdb.org/en/documents/green-economy-africa-waste-energy
25. Kabongo JD, Boiral O. Creating value with wastes and the paradox of embedded knowledge. Adv Strateg Manag, 2011; 28: 201–35. doi: 10.1108/S0742-3322(2011)0000028012
26. Verhelst S, Turner J, Sileghem L, Vancoillie J. Methanol as a fuel for internal combustion engines. Prog Energy Combust Sci., 2019; 70: 43–88. doi: 10.1016/j.pecs.2018.10.001
27. Chu PL, Majumder B, Hamm C, Kelly-Pitou K, Sherwin B. Environmental impact of biogas systems and their potential in Africa. Energy Sustain Soc., 2021; 11(1): 43. doi: 10.1186/s13705-021-00315-7
28. Owoade UK, Olise FS, Ogundele LT, Fawole OG, Olatunde OG. Solid waste characterisation and generation rates in urban and peri-urban centres of southwest Nigeria. Waste Manag Res., 2022; 40(8): 1102–12. doi: 10.1177/0734242X211059618
29. Ayodele TR, Ogunjuyigbe ASO, Alao MA. Life cycle assessment of different electricity generation sources from municipal solid waste: a case study of Ibadan, Nigeria. J Clean Prod., 2020; 259: 120854. doi: 10.1016/j.jclepro.2020.120854
30. Ebele AJ, Abam TKS, Etuk BR. Sustainable municipal waste management in developing countries using waste-to-energy approach. J Environ Manage, 2023; 344: 118622. doi: 10.1016/j.jenvman.2023.118622
31. Ntukidem EJ, Eze JI, Nwosu TC. Emerging circular economy strategies for pharmaceutical waste management in African cities: systematic scoping review. Waste Manag Res., 2024; 42(3): 222–35. doi: 10.1177/0734242X231198076