Sustainable Printing Waste Management in Developing Countries: A Qualitative Synthesis of Lagos State Practices

Nneka V. OHALLEM[1]
Patrick S. OKONJI[2]
Peter O. OLAYIWOLA[3]

[1,2&3] Department of Business Administration,
University of Lagos, Akoka, Yaba,
Lagos State, Nigeria.

Corresponding Author's Email: vedomnneka@yahoo.com

ABSTRACT

In developing countries, printing companies generate paper, ink, solvent, printing plate, and chemical waste that remain poorly documented and managed. This study synthesises evidence on sustainable printing waste management, focusing on waste reduction, source segregation, incineration, and the organisational, economic, regulatory, and infrastructural barriers to effective waste management in Lagos, Nigeria. A qualitative evidence synthesis guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement was conducted using a purposively selected corpus of 22 peer-reviewed studies. The evidence was analysed thematically within a circular economy and waste hierarchy framework. Findings indicate that waste reduction and cleaner production offer clear benefits, while recycling and hazardous waste management depend on effective source segregation. Evidence on incineration was limited and largely concerned municipal waste, highlighting the need for appropriate emissions controls. In Lagos, key barriers include inadequate infrastructure, regulatory weaknesses, limited awareness among business owners, and weak economic incentives. An empirical survey conducted by the authors further indicates that basic paper recycling is practised, whereas ink recycling, solvent management, and emissions control systems are largely absent. The study recommends regular waste audits, waste prevention at source, improved hazardous waste regulation, and further empirical research to strengthen sustainable printing waste management in Lagos and other developing economies.

Keywords: *Printing industry, Circular economy, Source segregation, Incineration,*

1. INTRODUCTION

Although printing is considered a clean service industry, printing houses are manufacturers which are intensive in materials. They use paper, ink and solvents and produce solid waste, wastewater and air emissions (Chawakitchareon, Hansuebsai, Jaewjareon, Chatrapanichkul, & Sooksamai, 2017). The wastes of the Ghanaian presses include paper and cardboard waste, ink containers, residual ink and chemicals (Amissah, Nduro, & Quansah, 2024). A study on Ghanaian printing houses was conducted to investigate the reasons for waste (Chea, 2008), while a study on Thai printing factories was conducted to determine the health risk due to VOCs and PM2.5 (Pongboonkhumlarp & Jinsart, 2022).

In Nigeria, these risks are particularly high because the country's main treatment and disposal systems are open dumping and burning, which are prevalent in low-income countries (Ferronato& Torretta, 2019), and the mandates are fragmented, with weak enforcement and

limited data available (Braide et al., 2026: Omokaro et al., 2026). However, aside from one study on Lagos presses (Ohallem, Okonji, & Olayiwola, 2026), the Nigerian evidence is limited to industrial, electronic, healthcare and general waste and not printing (Awodele, Adewoye, & Oparah, 2016; Ezeudu& Ezeudu, 2019; Uwah & Ibanga, 2021; Odeyingbo, Deubzer, & Ogunmokun, 2025), with Lagos, the country's biggest commercial hub, being a telling context for the question.

There are three practices that dominate the debate: reduction, segregation and incineration. Reduction and segregation are at the top of the waste hierarchy, but require capability and infrastructure, and incineration offers energy recovery. In Bangladesh, an analysis questions the rationale behind the cities in the global South's shift towards incineration instead of source segregation and recycling (Akther, Evans, & Millington, 2024).

This paper thus combines the evidence in three objectives: (1) to review the role of waste reduction, segregation and incineration in printing waste management; (2) to analyze the challenges of implementing waste reduction, segregation and incineration in Lagos, Nigeria; and (3) to synthesize evidence-based strategies for improving printing waste management in developing economies. It contributes with a consolidated evidence base which identifies how directly each source addresses Lagos, and a sequenced barrier and strategy framework.

2. LITERATURE REVIEW

2.1 Conceptual framework. This synthesis rests on two linked ideas, the circular economy and the waste hierarchy. Kirchherr, Reike, and Hekkert (2017) analysed 114 definitions and found that the circular economy is most often defined as a combination of reduction, re-use and recycling activities. The waste hierarchy supplies the ordering of those activities, ranking options from prevention at the top to disposal at the bottom (European Parliament & Council of the European Union, 2008). Together they imply that preventing waste at source is preferable to recovering it, and that recovery is preferable to treatment or disposal. This ordering organises the evidence that follows, because reduction, segregation and incineration sit at different levels of the hierarchy.

2.2 Printing waste and its environmental burden. Printing is materials-intensive, using paper, ink and solvents and generating solid waste, wastewater and air emissions (Chawakitchareon et al., 2017). The streams documented in Ghanaian presses include paper and cardboard, ink containers, residual ink and chemicals (Amissah et al., 2024), and Chea (2008) investigated the causes and sources of waste in printing houses in Accra and Kumasi. A qualitative study of offset printing businesses in Medan, Indonesia found that most operators discharged liquid waste directly into drains and mixed solid waste with household refuse, and that none reported receiving guidance from the environmental agency (Juwairiah, 2025). Exposure is a further concern: Pongboonkhumlarp and Jinsart (2022) analysed the health risk from volatile organic compounds and fine particulate matter in the printing industry. In developing economies these streams enter systems where open dumping and burning remain the dominant treatment and disposal routes (Ferronato & Torretta, 2019; Akpan & Uford, 2024; Ibanga & Akpan, 2024). Firm-level evidence is therefore scattered across single cases (Andrade et al., 2012; Chawakitchareon et al., 2017; Cooray et al., 2014).

2.3 **Waste reduction and cleaner production**. Reduction has the most quantified support. A life cycle assessment of aqueous inkjet printing for flexible packaging reported lower waste, carbon dioxide and VOC emissions than analog printing, with the largest gains in small-lot production (Kozake et al., 2021). In a Thai printing house, shorter set-up and job-change times

and a solvent-saving device cut emissions and washing solvent use (Hansuebsai, Kaosod, & Kanchanasing, 2020), and Aydemir, Yenidoğan, and Tutak (2023) review sustainability options across the print and packaging industry. Reduction also has a commercial logic, as the Sri Lankan firm adopted waste management practices to support profit maximisation (Cooray et al., 2014), and multi-firm case evidence from Danish printing SMEs shows that investment in environmental management can be justified strategically through complementary assets (Reyes-Rodríguez & Ulhøi, 2022). Two limits apply. These results come from firms with capital and technical capacity, and no study has costed such measures for a Nigerian press, so their transfer to small Lagos firms is an inference rather than a finding.

2.4 Segregation, classification and recovery. Segregation is the condition that makes recycling and hazardous waste handling possible. At firm level, the Thai printing house classified its waste into hazardous and non-hazardous streams and assigned a code to each, which gave a basis for auditing and for permitting treatment (Chawakitchareon et al., 2017), and Andrade et al. (2012) similarly framed hazardous waste management as a strategy for small firms. Once streams are separated, recovery can follow, as on-site conversion of printing house paper waste into cardboard lowered greenhouse gas emissions relative to conventional paper waste management (Levin et al., 2025). Downstream, the evidence is weaker. In Nigeria informal collectors handle most recyclables (Ezeudu & Ugochukwu, 2026), a waste audit at the University of Lagos found contaminated segregation bins despite an existing policy (Mbama, Otegbulu, Beverland, & Beattie, 2023), and Akther et al. (2024) show that in Bangladesh segregation and recycling are often displaced when treatment capacity is prioritised. Segregation evidence on printing waste specifically is therefore thin.

2.5 Incineration. Incineration offers volume reduction and energy recovery but sits near the bottom of the hierarchy. Cudjoe and Acquah (2020) assessed the environmental impact of municipal solid waste incineration in African countries, and Huang et al. (2024) found that health risks from 96 regulated waste-to-energy plants in China were within acceptable limits, with waste sorting and chimney height reducing them further. Akther et al. (2024) question why cities in the global South pursue incineration instead of source segregation and recycling. All of this evidence concerns municipal waste, and none addresses segregated printing residues such as ink-contaminated materials, so its relevance to printing is limited to residual streams that cannot be reduced or recovered.

2.6 **Governance and barriers in Nigeria.** Nigerian studies concentrate on adjacent streams and consistently point to organisational, economic, regulatory and infrastructural barriers. A systematic review of 84 articles on waste management in micro, small and medium enterprises identified limited finance, knowledge, experience and training as recurring barriers (Derhab & Elkhwesky, 2023). Ezeudu and Ezeudu (2019) found that limited expertise and information hinder circular economy implementation in industrial waste management. Omokaro, Michael, Efeni, Adeyanju, and Obomejero (2026) describe fragmented mandates, weak enforcement and limited data, and Odeyingbo, Deubzer, and Ogunmokun (2025) report incomplete implementation and noncompliance under the revised national e-waste framework, with informal collectors favouring valuable materials. Small and medium enterprises are also a neglected source of pollution in Nigeria, because the sector often escapes scrutiny despite federal regulations and enforcement agencies (Sridhar et al., 2018), and a survey of 153 food and beverage SMEs in Southwestern Nigeria found that about 15% lacked a waste management plan and 15.8% did not comply with wastewater discharge regulations, leading the authors to call for more regular and stringent enforcement (Aodu & Adejuwon, 2025). Kadhila, de Wit, and Schenck (2023) propose a conceptual framework for sustainable waste management in small municipalities in South Africa and Namibia. In Lagos itself, a study of industrial waste

found that about 20% of the waste generated was ignitable and concluded that legislation, enforcement and tracking of industrial waste need strengthening (Ozabor et al., 2024). Evidence from Lagos hospitals shows that a state agency intervention improved compliance and awareness (Awodele, Adewoye, & Oparah, 2016), which suggests that a licensed channel for hazardous waste is feasible in the state. For printing, only Ohallem, Okonji, and Olayiwola (2026) provide Lagos evidence, a survey of printing presses on recycling practices and operational cost reduction.

2.7 Research gap. Three gaps follow from this review. First, printing waste studies in developing economies are few (Chea, 2008; Cooray et al., 2014; Amissah et al., 2024), and the single Lagos study measured the adoption of recycling and its performance returns without synthesising barriers and strategies (Ohallem et al., 2026). Second, the three practices are studied at different scales, namely the firm, the collection system and the city, so their interdependence is rarely examined. Third, evidence on incineration is almost entirely municipal. This synthesis addresses them by connecting the three practices within one hierarchy-based framework.

3. METHOD

3.1 Research design. It is a qualitative evidence synthesis (secondary source). It adheres to the transparency guidelines of PRISMA 2020 (Page et al., 2021) for reporting of sources, eligibility and selection, and uses thematic synthesis (Thomas & Harden, 2008). The review was not registered and published sources were only used, therefore no ethical clearance was required.

3.2 Sources and corpus assembly. The corpus was compiled in a purposive manner from three routes (Fig. 1). The authors collected full-text articles related to printing waste, print and packaging sustainability and waste governance in developing economies. A research agent retained 20 records from 196 eligible records that were identified in targeted searches on the Consensus platform (semantic search of peer-reviewed literature) in October 2026. A preliminary search of PubMed was conducted on 19 October 2026, which yielded 58 records that were not filtered for inclusion. These routes were used to create a working corpus of 36 sources. A bibliographic verification step was then carried out, which excluded 19 sources for which it was not possible to fully confirm the publication details, resulting in 17 studies. Four additional sources were then identified: Ohallem et al., 2026 (the authors' own survey of Lagos printing presses), and three found by a FastTrack literature search (Chea, 2008; Cooray et al., 2014; Ferronato& Torretta, 2019; Mbama, Otegbulu, Beverland, & Beattie, 2023) conducted on 20 October 2026. The remaining 22 studies include ten on printing houses and processes, one on occupational exposure, six on Nigerian waste governance and two on other developing-economy governance and three on incineration. Selection was purposive and exhaustive coverage is not claimed.

3.3 Eligibility criteria. Sources were included if they were peer reviewed, in English, published between 2005 and 2026 and relevant to printing waste or, in the absence of printing evidence, industrial and healthcare waste in Nigeria, informal recycling, incineration, or circular economy governance in developing economies. Studies that did not include waste practice or policy were excluded from the analysis unless they were related to additive manufacturing, concrete printing, textile dyeing and printed electronics.

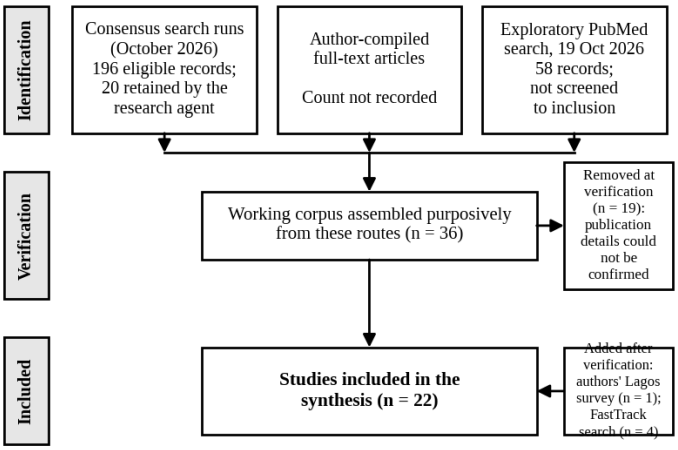


Fig. 1*Corpus assembly flow diagram (PRISMA 2020 informed)*

3.4 Appraisal and analysis. Proportionate judgment of quality was made due to the mixed case studies, experiments, reviews and models in the corpus. Sources were assessed for design transparency and venue, and directness (direct for printing, adjacent for Nigerian or other developing-economy waste systems, indirect for municipal incineration) determines the level of firmness of the conclusions. Thomas and Harden (2008) were followed in coding the findings line by line and developing the descriptive and then analytical themes in line with the objectives. There is a limitation that one reviewer coded the data.

4. RESULTS AND DISCUSSION

A single study on printing waste in the city of Lagos was found, which is a survey conducted by the current authors (Ohallem et al., 2026). Findings for Objective 2 are thus a mixture of the direct evidence and evidence from neighbouring Nigeria and similar contexts, and the transfer to Lagos printing firms is an inference. The aim of the reduction, segregation and incineration objective is:

4.1 Objective 1: Reduction, segregation and incineration

The evidence for reduction is the most obvious and quantified. A life cycle comparison revealed a 57% reduction in waste in small-lot packaging production and a 15% reduction in long runs when compared to analog printing, and 75% less carbon dioxide and 33% less VOC emissions in small-lot printing (Kozake et al., 2021). In a printing shop in Thailand, reducing set-up and job changing times reduced the emissions of CO_2 by 25.86% and saving on the daily washing solvent by up to 20% with the use of a plunger device (Hansuebsai, Kaosod, & Kanchanasing, 2020). No study has been costed for digital conversion of a Nigerian press, and low-capital measures are the safer ones to start with for small firms. Recovery is best after reduction: on-site reduction of printing house paper waste to cardboard reduces GHGs by 50% compared to conventional paper waste management (Levin et al., 2025).

A printing company in Thailand categorized hazardous and non-hazardous waste and assigned a waste code to each waste stream, providing a foundation for auditing and permitting treatment (Chawakitchareon et al., 2017). The disadvantage is that it is not maintained downstream where collection is not segregated: in Nigeria, informal collectors are currently doing most of the collection of recyclables (Ezeudu& Ugochukwu, 2026), and the evidence in Bangladesh (Akther et al., 2024) indicates that segregation is often neglected when treatment capacity is

prioritized. In Lagos, the authors attribute the lack of waste segregation in the city to the poor implementation of the policy as a waste audit at the University of Lagos revealed contaminated waste segregation bins and 99% of waste going to landfill despite the policy in place (Mbama et al., 2023). The survey of 188 staff from printing establishments in Shomolu and Ikeja, Lagos, revealed that basic paper practices had high scores (between 4.04 and 4.12), while ink recovery, solvent recovery, wastewater treatment and emissions minimization and take-back schemes had low scores (between 2.14 and 2.23) (Ohallem et al., 2026). Thus, segregation is a must, but not a cure-all.

In the corpus, all incineration studies refer to municipal waste, and there are no studies on segregated printing waste. Overall, health risk indices and cancer risks were within the acceptable limits for the 96 regulated waste-to-energy plants in China, and the sorting and the height of the chimneys reduced health risks further (Huang et al., 2024). Incineration is at the bottom of the hierarchy for residues which cannot be reduced or recovered, for printing.

4.2 Objective 2: Challenges in Lagos and comparable economies

Organizational barriers are related to knowledge, where lack of expert knowledge and lack of information have been a challenge in implementing the circular economy in low and middle-income countries as the Nigerian industrial cases show (Ezeudu& Ezeudu, 2019). Economic logic is the determining factor for adoption and collection: a printing company in Sri Lanka adopted waste management to support profit maximization (Cooray et al., 2014), while in Lagos recycling practice was not significantly associated with cost reduction (Ohallem et al., 2026) and in Nigeria, the informal e-waste collectors focus on valuable materials, so paper and cardboard are more likely to be recovered than the remaining ink and solvents that require paid treatment (Odeyingbo, Deubzer, & Ogunmokun, 2025).

The most consistent barrier reported is regulation, and it is not so much that there are no rules, but rather that they are not enforced and that they do not cover all. A new national e-waste framework in Nigeria was introduced, but it failed to be fully implemented, with some level of noncompliance (Odeyingbo et al., 2025). The lack of advanced systems in the Lagos survey is due to poor enforcement and lack of funding (Ohallem et al., 2026). Infrastructure is important because hazardous streams must have a licensed destination.

4.3 Objective 3: Strategies

The most effective strategies start within the company: cleaner production processes (digital processes, short changeover, solvent-saving devices, informed ink selection) (Aydemir et al., 2023; Hansuebsai et al., 2020; Kozake et al., 2021), waste audit with stream classification (Chawakitchareon et al., 2017) and on-site recovery (Levin et al., 2025).

In addition to the firm, the evidence suggests coordination and a licensed channel, and Lagos already has a channel for hazardous healthcare waste. The Lagos Waste Management Authority's intervention programs in seven hospitals led to an improvement in compliance and awareness (Awodele, Adewoye, & Oparah, 2016). Omokaro et al. (2026) emphasize the need for a national policy that is unified and has enforceable extended producer responsibility and formalization of informal workers, while Odeyingbo et al. (2025) suggest targeted training and financial incentives to encourage waste to be directed to formal systems. For segregated residuals, energy recovery is best considered as the last resort (Huang et al., 2024).

4.4 Integrative framework

The objectives are put together in a sequence (Table 1). The measures at the firm level are first because they are inexpensive, within the control of the press owners, and have direct evidence

of printing. This is followed by cluster level coordination, as segregated streams must be collected and treated under license. But the limiting factor is system-level reform, for if that is not enforced, the previous steps have no impact.

The results help to clarify the waste hierarchy in resource-limited environments. The order of the printing is correct, but the lower levels rely on the upper levels: Incineration is OK after segregation, hazardous handling is OK after classification. The hierarchy in Lagos thus operates as a dependency chain, with the weakest link being the regulatory capacity that links firm-level practice with the licensed downstream channels. This makes the focus on reduction, re-use and re-cycle identified by Kirchherr, Reike, & Hekkert (2017) in the definitions of circular economy relevant as governance conditions influence whether this takes place or not.

5. RECOMMENDATIONS

Based on the findings, printing firm owners and managers should carryout regular waste audits, minimise material waste via improved production planning, and introduce source segregation to facilitate recycling and safe disposal. Relevant environmental regulatory agencies should improve hazardous waste regulation by strengthening monitoring, providing clear guidance on the handling of printing waste, and ensuring compliance with applicable requirements for hazardous waste and emissions control. Lastly, researchers should carryout empirical studies of printing firms in Lagos State, with particular attention to ink and solvent waste, incineration practices, and the association between waste management practices and operational outcomes.

REFERENCES

Akpan, S. J., & Uford, I. C. (2024). Effect of fuel subsidy removal on purchase of consumer goods in Nigeria: A literature review. *International Journal of Economics, Business and Social Science Research*, *2*(4), 30-38.

Akther, S., Evans, J., & Millington, N. (2024). Why do cities in the global South pursue waste incineration rather than source segregation and recycling? Insights from Bangladesh. *Frontiers in Sustainability, 5,* Article 1496075. doi:10.3389/frsus.2024.1496075

Amissah, E. K., Nduro, K., & Quansah, P. A. (2024). Towards greener printing: Examining waste disposal innovations in the Ghanaian printing industry. *International Journal of Research and Innovation in Social Science, 8*(3), 1244–1264. doi:10.47772/IJRISS.2024.803092

Andrade, L. C., Míguez, C. G., Gómez, M. C. T., & Bugallo, P. M. B. (2012). Management strategy for hazardous waste from atomised SME: Application to the printing industry. *Journal of Cleaner Production, 35*, 214–229. doi:10.1016/j.jclepro.2012.05.014

Aodu, B. A., & Adejuwon, O. O. (2025). Compliance with environmental regulations: Insights from small and medium scale enterprises in the food and beverage sector in Southwestern Nigeria. *Global Journal of Environmental Science and Sustainability, 2*(1), 55–69. doi:10.69798/60361997

Awodele, O., Adewoye, A. A., & Oparah, A. C. (2016). Assessment of medical waste management in seven hospitals in Lagos, Nigeria. *BMC Public Health, 16*, Article 269. doi:10.1186/s12889-016-2916-1

Aydemir, C., Yenidoğan, S., & Tutak, D. (2023). Sustainability in the print and packaging industry. *Cellulose Chemistry and Technology, 57*(5–6), 565–577. doi:10.35812/cellulosechemtechnol.2023.57.51

Braide, E. A., Akpan, A. B., Uford, I. C., & Akpan, S. J. (2026). Biodegradable Packaging and Consumer Buying Behaviour of Fast-Moving Consumer Goods in Akwa Ibom State, Nigeria. *International Journal of Economics, Business and Social Science Research, 4*(1), 133-144.

Chawakitchareon, P., Hansuebsai, A., Jaewjareon, K., Chatrapanichkul, V., & Sooksamai, W. (2017). Environmental waste management for the printing industry: A case study of CU Printing House, Thailand. *Nihon Insatsu Gakkaishi, 54*(1), 43–48. doi:10.11413/nig.54.043

Chea, A. C. (2008). Causes and sources of waste in the printing industry in Ghana: A study of printing houses in the cities of Accra and Kumasi. *International Business Research, 1*(3). doi:10.5539/ibr.v1n3p22

Cooray, N., Murshidha, F., Senanayake, N., Prashanty, R., Rathnasinghe, U., & Dharmika, J. (2014). Adopting and implementing waste management practices in the printing industry: A Sri Lankan case. *Journal of Accounting Panorama, 1*, 102–114.

Cudjoe, D., & Acquah, P. (2020). Environmental impact analysis of municipal solid waste incineration in African countries. *Chemosphere*, Article 129186. doi:10.1016/j.chemosphere.2020.129186

Derhab, N., & Elkhwesky, Z. (2023). A systematic and critical review of waste management in micro, small and medium-sized enterprises: Future directions for theory and practice. *Environmental Science and Pollution Research, 30*(6), 13920–13944. doi:10.1007/s11356-022-24742-7

European Parliament & Council of the European Union. (2008). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. *Official Journal of the European Union, L 312*.

Ezeudu, O. B., & Ezeudu, T. S. (2019). Implementation of circular economy principles in industrial solid waste management: Case studies from a developing economy (Nigeria). *Recycling, 4*(4), Article 42. doi:10.3390/recycling4040042

Ezeudu, O. B., & Ugochukwu, U. C. (2026). Assessing the contributions of informal waste management sector and its economic potentials in Nigeria: Challenges and opportunities for macro-level circular economy implementation. *Waste Management & Research*. Advance online publication. doi:10.1177/0734242X251405958

Ferronato, N., & Torretta, V. (2019). Waste mismanagement in developing countries: A review of global issues. *International Journal of Environmental Research and Public Health, 16*(6), Article 1060. doi:10.3390/ijerph16061060

Hansuebsai, A., Kaosod, A., & Kanchanasing, T. (2020). A new environmental performance index based on the carbon footprint, VOC emissions, and waste in a printing house. *Engineering Reports*, Article e12165. doi:10.1002/eng2.12165

Huang, Z., Cui, J., Boré, A., Ma, W., Zhang, Z., Qiao, Z., ... Fellner, J. (2024). Health risk assessment of municipal solid waste incineration emissions based on regression analysis. *Eco-Environment & Health, 3*(3), 338–346. doi:10.1016/j.eehl.2024.01.009

Ibanga, S., & Akpan, A. (2024). Road infrastructure and socio-economic development in Akwa Ibom State, Nigeria. *ADUN Journal of Arts, Management and Social Sciences*, *1*(2), 351-367.

Kadhila, T., de Wit, M. P., & Schenck, R. (2023). A conceptual framework for sustainable waste management in small municipalities: The cases of Langebaan, South Africa and Swakopmund, Namibia. *Environmental Science and Pollution Research, 30*. doi:10.1007/s11356-023-26904-7

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232. doi:10.1016/j.resconrec.2017.09.005

Kozake, K., Egawa, T., Kunii, S., Kawaguchi, H., Okada, T., Sakata, Y., ... Itsubo, N. (2021). Environmental impact assessment of flexible package printing with the "LUNAJET" aqueous inkjet ink using nanodispersion technology. *Sustainability, 13*(17), Article 9851. doi:10.3390/su13179851

Levin, K. J., Costa, D. dos S., Urb, L., Peikolainen, A.-L., Venderström, T., & Tamm, T. (2025). Feasibility of a sustainable on-site paper recycling process. *Recycling*, *10*(2), Article 67. doi:10.3390/recycling10020067

Mbama, C. A., Otegbulu, A., Beverland, I., & Beattie, T. K. (2023). Solid waste recycling within higher education in developing countries: A case study of the University of Lagos. *Journal of Material Cycles and Waste Management, 25*(2), 886–898. doi:10.1007/s10163-022-01569-5

Odeyingbo, O. A., Deubzer, O. K., & Ogunmokun, O. A. (2025). Assessment of the impact of the revised national e-waste framework on the informal e-waste sector of Nigeria. *Recycling*, *10*(3), Article 117. doi:10.3390/recycling10030117

Ohallem, N. V., Okonji, P. S., & Olayiwola, P. O. (2026). Waste recycling practices, resource conservation, and operational cost reduction in Nigerian printing press organisations: Empirical evidence from Lagos State. *International Journal of Education, Management Sciences and Professional Studies, 3*(2), 39–60. doi:10.66993/ijemps23486202639-60

Omokaro, G. O., Michael, I., Efeni, O., Adeyanju, O., & Obomejero, J. (2026). Waste management in Nigeria: Systemic failures, circular economy pathways and sustainable solutions. *Environmental Development*, Article 101363. doi:10.1016/j.envdev.2025.101363

Ozabor, F., Wekpe, V. O., Tega, E., & Ojoh, C. O. (2024). Spatial assessment of pollutants concentration in air and soils impacted by industrial wastes in Lagos State, Nigeria. *Environmental Research Communications, 6*(6), 065013. doi:10.1088/2515-7620/ad5790

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, Article n71. doi:10.1136/bmj.n71

Pongboonkhumlarp, N., & Jinsart, W. (2022). Health risk analysis from volatile organic compounds and fine particulate matter in the printing industry. *International Journal of Environmental Science and Technology*, *19*(9), 8633–8644. doi:10.1007/s13762-021-03733-0

Reyes-Rodríguez, J. F., & Ulhøi, J. P. (2022). Justifying environmental sustainability in small- and medium-sized enterprises: An analysis of complementary assets in the printing industry. *Business Strategy and the Environment, 31*(1), 59–75. doi:10.1002/bse.2874

Sridhar, M. K. C., Coker, A. O., & Achi, C. N. (2018). Pollution from small and medium size enterprises: Less understood and neglected sources in Nigerian environment. *Journal of Environmental and Analytical Toxicology, 8*(2), 1–7. doi:10.4172/2161-0525.1000557

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology, 8*, Article 45. doi:10.1186/1471-2288-8-45

Uwah, U. E., & Ibanga, S. E. (2021). Public financial management reforms and economic development in Nigeria's Fourth Republic. *International Journal of Scientific Research in Social Sciences and Management Studies*, *5*(1), 44-54.

Table 1

Barrier and strategy framework for printing waste in Lagos and comparable economies

Barrier dimension	**Priority strategy**	**Lead actors**
Organizational	Waste audit, stream classification, owner advisory service	Press owners, trade associations
Economic	Reduction to cut cost, financial incentives for formal channels	Firms, regulators
Regulatory	Printing-specific waste classification, licensing, formalization of collectors	Environmental regulators
Infrastructural	Shared cluster collection, licensed hazardous handlers, recycler partnerships	Waste agencies, private operators

Source: Author's synthesis of reviewed studies