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022-Assessment of Waste Management Practices in Nigerian Red Bricks Production Process

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Abstract: The red bricks production in Nigeria is traditionally carried out which generate significant amount of waste. Improper management of the waste contribute to environmental degradation, reduce production efficiency and pose health risks to workers and the community at large. Therefore, the present study investigated the current waste management practices in Nigerian red bricks production process with a view to propose for a better and a reliable approach. The study employed a quantitative survey research design for data collection. Descriptive and inferential statistics were used for analysis of the data collected through the quantitative study. The study conducted shows that most producers in the study content rely on traditional approach with minimal consideration on waste minimization or reuse. Common waste in Nigerian red bricks production process are Organic scraps, glass and paper scraps. Recycling methods and sanitary landfill are the two most common waste management practices adopted in Nigerian red bricks production process. The study concludes that there is lack of a structured waste management practice in Nigerian red bricks production process and recommends for future research on modern approach such as digital technologies adoption for waste reduction in red bricks production process.

Keywords: *Red bricks, Production, Process, Waste, Management*

1. INTRODUCTION

The rapid urbanization witnessed in developing countries such as Asia and Africa has led to a substantial increase in industrial waste generation (Kofoworola, 2007; Maalouf and Mavropoulos, 2022; Valenzuela-Levi, 2019; Zhao *et al*., 2020). However, the corresponding disposal strategies, along with constraints in land resources and finances, compounded by unorganized public behaviour, have resulted in ineffective policy implementation and monitoring (Zhang *et al*., 2024). This lack of systematic and targeted orientation, combined with blind mapping, has led to inefficient development in many developing countries to include Nigeria. Furthermore, the generation of industrial waste is increasing on a daily basis, presenting a significant challenge to waste reduction efforts (Ge *et al*., 2024; Wang and Li, 2020; Xiao *et al.,* 2023). Mor and Ravindra, 2023). In other words, the red bricks production process in Nigerian construction industry is plagued with waste generation, resulting in environmental degradation that consequently reduce productivity. Despite the existing waste reduction strategies espoused in the literature, the industry still relying on traditional method of production (Aka *et al.,* 2019). This implies that in many parts of Nigeria, red bricks production is still largely manual despite the large application of modern waste management techniques. Hence, there is a critical importance of establishing a comprehensive and sustainable approaches to eliminate waste that emerges from red brick production specifically in Nigeria and other developing nations across the globe. Alaa *et al*. (2013) researched on the development of bricks from waste materials. The study discovered that brick produced from waste is useful to provide potential and sustainable solution to waste management problems. Similarly, Lissy *et al*. (2018) and Jiang *et al* (2019) undertook a research on the energy efficient production of clay bricks using industrial waste. The study undertook an experiment to reduce the brick firing temperature in the kiln to about 600 ^{0}C thereby reducing the cost of production and making the whole process environmental-friendly. Zhang *et al*. (2024) assessed the waste management challenges in developing regions industries using case studies of a comprehensive review and future perspectives for Asia and Africa. The study submitted the rather than solely focusing on recycling, the study proposes waste sorting at the source, optimization of landfill practices, thermal treatment measures, and strategies to capitalize on the value of waste as more pertinent solutions aligned with local realities. In addition, it was found that barriers to optimizing management systems arise from socio-economic factors, infrastructural limitations, and cultural considerations.

It is imperative to note that the current study aims to assess the current waste in Nigerian red bricks production process and investigate the waste management practices in the study context. Though, the literature shows that modern production strategies such as digital tools in clay bricks mass housing production could be a solution to the waste generated in red bricks production. However, this has to be experimentally investigated in Nigerian construction industry.

Premised on aforesaid, this study assesses the various forms of waste in Abuja Nigerian red bricks production

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process and investigates the current waste management practices in the study context. This study's outcome has the potential to guide industry stakeholders and policymakers in promoting the use of modern technologies for waste reduction in red bricks production process, thereby facilitating more efficient and sustainable red bricks production practices with the use of local building materials specifically in the developing nations such as Nigeria.

2. METHODOLOGY

. This study utilized a quantitative survey research design to systematically collect data from a targeted population. In the quantitative survey research, astructured questionnaire was employed to collect the necessary data from the participants of the study (Nworgu, 2016). The study population composed of key professionals within Abuja's bricks manufacturing factories that are directly involved in or have knowledge about construction waste management. In line with this, a preliminary investigation undertaken, with the use of snowball sampling, revealed a total population size of 236 in five different red bricks factories in the study area.The sampling frame for this study is purposive as it made up of workers that have been working in the five selected red brick manufacturing factories in the study context. The selected factories are the one the researcher discovered during the study, and the selected workers in each of the factories are the one that were available and ready to participate in the survey study. They were also directly involved in or have knowledge about waste management. Based on the purposive sampling adopted for the study, 148 participants were obtained from the 236 targeted study population. This is because it is this number that meet up with the study's selection criteria of respondent's having experience in waste management in red bricks production process.The use of structured questionnaire was considered to be more appropriate for data collection in this study. The questionnaire was designed on a five-point Likert's scale format with three sections. The first section addressed the profile of the study respondents, while the second section was based on the various forms of waste applicable to red bricks production process in Nigeria. The last section looked into the existing waste management practices in the study context.All the data obtained in the study was analysed quantitatively by the researchers. This implies that the analysis of data wasconducted with the use of descriptive and inferential statistics (Pallant, 2013).

3. RESULTS AND DISCUSSION

At the time this research was conducted, a total of 148 structured questionnaires were distributed to bricks manufacturing workers in five brick manufacturing factories in Abuja. Out of these 148, 110 questionnaires were completed and retrieved, yielding a response rate of approximately 74.3%, which is considered adequate and acceptable for quantitative survey research (Wu *et al.,* 2022).

3.1 Demographic Characteristics of Respondents

TABLE 1: DEMOGRAPHIC VARIABLE

	Category	Frequency (f)	Percentage (%)
Gender	Male	80	72.7
	Female	30	27.3
	Total	**110**	**100**
Age Range	18–30	28	25.5
	31–40	42	38.2
	41–50	26	23.6
	51 and above	14	12.7
	Total	**110**	**100**
Highest Educational Qualification	ND/NCE	8	7.3
	HND/B.Sc.	45	40.9
	M.Sc./M.Tech	40	36.4
	Ph.D.	17	15.5
	Total	**110**	**100**
Years of Experience	Less than 5	20	18.2
	5–10	42	38.2
	11–15	28	25.5%
	Above 15	20	18.2%
	Total	**110**	**100**

Table 1 depicts that the data indicates a significant gender disparity among respondents, with 72.7% male and 27.3% female participants. This imbalance suggests a male-dominated sample, which may reflect broader trends in the construction industry, where men often outnumber women. Understanding the implications of this gender distribution is crucial, as it can influence the perspectives and experiences shared in the survey. The age distribution shows that the majority of respondents fall within the 31-40 age range (38.2%), followed by 18-30 (25.5%) and 41-50 (23.6%). The relatively low percentage of respondents ages 51 and above (12.7%) suggests a younger workforce, which may be more adaptable to new technologies and practices (Aka *et. al.,* 2019). The educational qualifications reveal that 40.9% of respondents were HND/B.Sc holders, while 36.4% have an M.Sc./M.Tech. while 15.5% were PhD holders as at when the study was conducted. The experience data indicates that 38.2% of respondents have 5-10 years of experience, while 18.2% have less than 5 years and 18.2% have over 15 years. This distribution suggests a mix of relatively new and seasoned professionals, which can enrich the survey findings by combining fresh perspectives with established knowledge.

3.2 The various forms of waste in Nigerian Red bricks production process

Table 2 presents the ranking of waste in red brick production and highlights a dual dimension of sustainability challenges: the adoption of waste-derived materials as inputs and the persistence of process-related inefficiencies during production. The findings show a clear hierarchy in terms of utilization waste, reflecting both material availability and systemic bottlenecks within Nigerian brickmaking practices.

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TABLE 2: WASTE IN RED BRICKS PRODUCTION PROCESS

Waste materials	MIS	SD	Interpretation
Organic scraps	4.50	0.70	Very high utilization
Glass	4.36	0.75	Very high utilization
Paper scraps	4.27	0.79	Very high utilization
Fly ash–lime gypsum	4.23	0.76	High utilization
Ground granulated blast furnace slag	4.14	0.81	High utilization
Limestone powder scraps	3.91	0.87	High utilization
City sewage sludge	3.68	0.95	Moderate to high utilization
Ash from bottom of thermal power plant	3.73	0.91	Moderate to high utilization
Bagasse	3.82	0.88	Moderate to high utilization
Cotton scraps	3.55	0.89	Moderate utilization
Used coffee grounds	3.50	0.92	Moderate utilization
Brewing sludge	3.18	1.01	Moderate utilization
Kraft pulp scraps	3.23	0.94	Moderate utilization
Reservoir sediment	3.27	0.97	Moderate utilization
Welding recycling facility chips	2.95	1.02	Low utilization
Textile effluent treatment waste	2.73	1.07	Low utilization
Petroleum effluent treatment debris	2.68	1.10	Low utilization
Olive mill effluent	2.64	1.12	Low utilization
Cigarette filters	2.55	1.11	Lowest utilization
Several sample tests before mining	3.12	0.98	Moderate utilization
Excessive waiting for the needed materials (clay or shale admixtures from the mining site to the factory) and waiting for the repair of production machine while the work is in progress	3.47	1.03	Moderate utilization
Excessive stocking of clay or shale admixtures regardless of when they will be needed for production	3.05	0.95	Moderate utilization
Excessive or long distance covered from the store where clay or shale admixtures are temporarily kept to the production machine	2.89	1.01	Low utilization
Over glazing and re-glazing of bricks that are not uniform in color	3.42	1.07	Moderate utilization

On the material utilization side, organic scraps (MIS = 4.50, Rank 1), glass (MIS = 4.36, Rank 2), and paper scraps (MIS = 4.27, Rank 3) emerged as the most widely encountered waste. This confirms the arguments of Jiang *et al.* (2019) that organic residues, glass, and paper are among the most feasible waste types for reintegration due to their abundance, relatively simple processing requirements, and strong recycling potential. Their high adoption also reflects the global trend towards circular construction practices, where easily available municipal and household waste are diverted from landfills and converted into construction inputs. Similarly, industrial by-products such as fly ash lime gypsum (MIS = 4.23, Rank 4) and ground granulated blast furnace slag (MIS = 4.14, Rank 5) ranked high, corroborating Ibrahim *et al.* (2022) and Dabaieh *et al.* (2020) that highlighted their benefits as supplementary cementitious materials. These materials improve brick density, durability, and strength while reducing dependence on energy-intensive Portland cement, thus aligning with the industrial symbiosis model of waste valorization. In contrast, hazardous and less manageable waste such as cigarette filters (MIS = 2.55, Rank 20), olive mill effluent (MIS = 2.64, Rank 19), and petroleum effluent debris (MIS = 2.68, Rank 18) recorded the lowest utilization rates. As Jiang *et al.* (2019) and Himabindu *et al.* (2024) note, these waste pose significant risks due to their chemical toxicity, stabilization difficulties, and potential to compromise product integrity. Their low adoption reflects industry hesitance and a lack of regulatory or technical frameworks for their safe integration into building materials. Similarly, copper mining waste (MIS = 2.77) and textile effluent sludge (MIS = 2.73) remain underutilized, highlighting the technological and environmental barriers in handling heavy-metal-laden and chemically unstable industrial wastes. Beyond material inputs, the analysis of process-related inefficiencies (items 21-28) reveals critical sources of waste within the production cycle. The most prevalent was breaking of bricks during transportation from the production machine to storage (MIS = 3.58, SD = 0.96), underscoring weaknesses in material handling and logistics, which Aka *et al* (2019) linked to poor supervision, fragile handling practices, and suboptimal factory layouts. Excessive waiting for materials and machine repairs (MIS = 3.47, SD = 1.03) was another significant issue, consistent with lean manufacturing critiques (Jørgensen and Emmitt, 2008), where waiting time is identified as a major form of production waste. This indicates poor preventive maintenance and inadequate synchronization of mining-to-factory operations. Quality-related inefficiencies such as over-glazing and re-glazing of bricks (MIS = 3.42, SD = 1.07) and overheating or excessive firing (MIS = 3.36, SD = 1.08) reflect inadequate process monitoring and thermal regulation in kiln operations. Jiang *et al* (2019) emphasized that such practices not only waste energy but also raise rework rates, inflating costs and undermining environmental efficiency. Other moderate issues included excessive drying of bricks (MIS = 3.21, SD =

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0.92) and excessive stocking of admixtures (MIS = 3.05, SD = 0.95), both indicative of weak production planning and poor alignment between demand forecasting and supply management. Finally, long-distance material movement within factories (MIS = 2.89, SD = 1.01), though ranked lowest among process inefficiencies, reveals hidden inefficiencies in facility design that contribute to time losses and breakages, a challenge well-documented in lean production literature. Taken together, the results demonstrate that while Nigerian brick producers have increasingly adopted accessible waste such as organics, glass, and industrial by-products as inputs, internal inefficiencies in production processes remain equally critical sources of waste. This dual reality suggests that sustainable improvement requires both technological integration of safe waste-derived inputs and systemic reforms in production management, including digital technologies adoption, lean workflows, preventive maintenance, and facility redesign. This finding resonates with the sustainability discourse advanced by Ibrahim *et al.* (2022) and Xiao *et al.* (2023), which emphasize that reducing waste in construction materials requires a combined focus on input substitution and process optimization.

3.3 Current Waste Management Practices adopted in Nigerian Red Bricks Production Process

Table 3 revealed that recycling methods (RII = 0.764) are perceived as the most important waste management practice among professionals engaged in red bricks production in the study context. This was followed closely by sanitary landfill (RII = 0.725). In contrast, more traditional and environmentally harmful practices such as waste burying (RII = 0.522) and open dumping (RII = 0.500) were rated significantly lower, suggesting a notable transition towards sustainable waste management practices within the sector.

The prioritization of recycling aligns with recent literature emphasizing its critical role in advancing circular economy practices in the construction industry. According to Rojas-Valencia and Aquino (2019), the incorporation of recycled materials in brick production not only enhances sustainability but also maintains the structural integrity required for construction applications. A more recent study by Chauhan *et al.* (2023) demonstrated that geopolymer bricks made from recycled industrial waste exhibited comparable compressive strength and thermal resistance to conventional clay-fired bricks, thereby validating their practical applicability in developing countries. This growing preference for recycling also reflects global efforts to reduce construction and demolition (C&D) waste. Wu *et al.* (2022) emphasized that recycling not only diverts waste from landfills but also reduces the environmental footprint associated with the extraction and processing of virgin materials. Similarly, Akinade *et al.* (2020) highlighted the role of recycling in enhancing resource efficiency and minimising the carbon emissions typically associated with red bricks production in emerging economies. Although sanitary landfill is traditionally regarded as a disposal method rather than a sustainable practice, its relatively high RII score depicts that respondents acknowledge its role as a controlled and safer alternative to open dumping or informal disposal. Sanitary landfills, when properly managed, can help contain harmful leachates and reduce greenhouse gas emissions, thereby minimizing their ecological impact (Mohammed *et al.,* 2020). This reflects a broader shift toward regulated waste management infrastructure, even in areas where advanced recycling systems may not be fully established. On the other hand, open dumping and waste burying are increasingly discouraged due to their association with soil contamination, air pollution, and public health hazards (Akhtar and Sarmah, 2018). Their low rankings in the current study mirror existing scholarly consensus that such practices are unsustainable and should be phased out in favor of more environmentally responsible alternatives. The findings thus reflect a progressive shift among Nigerian construction professionals toward waste management practices that align with global sustainability goals. This is consistent with the "waste hierarchy" model, which places recycling above disposal-oriented practices and prioritizes environmental efficiency and material recovery (European Commission, 2020). Consequently, the emphasis on recycling and regulated disposal methods signals an evolving mindset within the red bricks production sector one that increasingly values both environmental stewardship and operational efficiency.

Table 3: Waste management practice in red bricks production process

S/N	Waste management practice	5	4	3	2	1	ΣW	RII	Remark
1	Recycling methods are adopted	35	40	20	10	5	420	0.764	V.I
2	Sanitary landfill is commonly used	30	32	25	18	10	399	0.725	V.I
3	Waste management plans are in place	28	36	22	10	4	374	0.680	V.I
3	Composting is integrated in our system	25	30	28	18	9	374	0.680	V.I
3	Documentation of waste disposal is in place	22	34	28	18	8	374	0.680	V.I
6	Regular waste audits are carried out	24	30	30	16	10	372	0.676	V.I
7	Anaerobic digestion is used for organics	20	28	26	24	12	350	0.636	V.I
8	Incineration is used to reduce waste volume	18	26	30	20	16	340	0.618	V.I
9	Waste burying is a common approach	12	18	30	25	15	287	0.522	I
10	Open dumping is still being practiced	10	15	20	30	45	275	0.500	I

4. CONCLUSION

This study investigated the forms of waste and waste management practices in Nigerian red bricks production process. The results revealed a growing inclination toward sustainable practices, such as recycling and sanitary landfilling, while environmentally harmful approaches like open dumping are diminishing.

The study concludes that there is lack of a structured waste management practice in Nigerian red bricks production process and recommends for future research

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on modern approach such as digital technologies adoption for waste reduction in red bricks production process.

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