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Evaluation of Walkway Tile Made from Municipal Solid Residues and its Effect on Environmental Management

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ABSTRACT

Background and Objective: The exploration of alternative applications for municipal solid residues for an innovative solution as residue management is crucial for achieving environmental sustainability goals. The contributions to the development of sustainable residue management practices that reduce residue generation, promote resource conservation, and minimize environmental pollution. This research study aims to evaluate the viability and environmental impact of utilizing these residues in the production of walkway tiles. **Materials and Methods:** A combination of laboratory assessments and a field-based survey was conducted to evaluate MSR recycling potential. The study incorporated a structured questionnaire administered to 150 respondents at the Oyo State Ministry of Environment (OYSME) Secretariat in Ibadan, where key stakeholders are involved in addressing national goals on desertification, deforestation, pollution, and residue management. **Results:** The study's findings showed that the majority of the respondents were male, with a percentage of 53.13%, and females were 46.87%, and all of the respondents are worried about the menace of residues on our environment. The majority of the workers, 68.75%, are aware of the recycling of MSR for other products, and 31.25% of the workers are concerned about the increasing volume of MSR generated in some areas. 63.00% of workers perceived that MSR walkway tiles have a positive environmental impact, 28.00% of workers liked their durability, and 9.00% of workers appreciated their beauty. A high percentage of respondents, 87.00%, are willing to use MSR tiles for walkway application and are ready to purchase if available, which shows the high acceptability of tiles made from MSR through the recycled technique. **Conclusion:** The study highlights municipal solid residues' (MSR) potential as a sustainable construction material and the need for effective residue management rules to maximize MSR resource value.

KEYWORDS

Evaluation, walkway tiles, municipal solid residues, environmental management

INTRODUCTION

The rapid pace of urbanization and industrialization has significantly increased the generation of municipal solid residues (MSR), posing a major challenge for environmental sustainability[1,2]. Traditional waste management approaches, such as landfilling and incineration, are increasingly criticized for their negative

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environmental impacts, including pollution and greenhouse gas emissions[3,4]. These methods not only exacerbate environmental degradation but also fail to tap into the latent potential of waste materials as valuable resources[5,6]. Consequently, exploring alternative applications for MSR has become a crucial area of research aimed at promoting resource conservation, reducing waste generation, and advancing circular economy principles[7,8]. One promising approach to sustainable MSR management involves transforming these residues into value-added products, such as walkway tiles, which can alleviate landfill pressures while supporting green construction practices[9,10]. This innovation aligns with global sustainability goals by reducing dependence on virgin materials and lowering the carbon footprints associated with construction activities. The construction sector, as one of the largest consumers of raw materials and energy, is responsible for a considerable proportion of global greenhouse gas emissions and ecological disruption[11,12]. Developing environmentally friendly construction materials from recycled MSR could therefore provide a dual benefit: managing waste sustainably while mitigating the construction sector's environmental impact. The rationale behind this study lies in the urgent need to address the intertwined challenges of waste accumulation and the unsustainable resource demands of the construction industry[13]. While preliminary studies have highlighted the potential of recycled MSR in construction materials, there remains a scarcity of comprehensive evaluations regarding their physical, mechanical, and environmental performance[14]. A thorough investigation into these aspects is essential to validate the feasibility of MSR-based walkway tiles and to provide empirical evidence supporting their adoption in construction and urban infrastructure projects. This research, therefore, is designed to evaluate the viability and environmental impact of using MSR for the production of walkway tiles. Specifically, it aims to assess the physical and mechanical properties (including compressive strength, flexural strength, density, and durability) of tiles made from MSR and to evaluate their environmental implications, such as waste diversion efficiency and potential for reducing carbon emissions. The ultimate goal is to contribute to the development of sustainable residue management practices that enhance resource efficiency, minimize environmental pollution, and promote a circular economy. Thus, the purpose of this study is to investigate the potential of municipal solid residues as sustainable materials for walkway tile production, providing a viable solution to waste management challenges and advancing environmental sustainability goals.

MATERIALS AND METHODS

Study area: The study was conducted between January and October, 2023 at the Oyo State Ministry of Environment (OYSME) Secretariat, located in Ibadan, Nigeria. This location was chosen due to its pivotal role in implementing national policies related to desertification, deforestation, pollution control, and residue management, providing a strategic environment for evaluating the potential use of municipal solid residues for sustainable product development. In addition, environmental impact parameters, such as trash reduction efficiency and potential contributions toward sustainable waste management, were also evaluated.

Data collection: A combination of laboratory assessments and a field-based survey was conducted to evaluate MSR recycling potential. The study incorporated a structured questionnaire administered to 150 respondents at the Oyo State Ministry of Environment (OYSME) Secretariat in Ibadan, where key stakeholders are involved in addressing national goals on desertification, deforestation, pollution, and residue management. The questionnaire covered demographic information, awareness of recycling practices, perceptions of the environmental impact, and willingness to use MSR tiles.

Ethical statement: This study involved the participation of human subjects through the administration of a structured questionnaire. Ethical approval was obtained from the Forestry Research Institute of Nigeria, P.M.B. 5050, Jericho Hill, Ibadan. Nigeria. All participants were informed about the purpose of the study and provided their voluntary informed consent before participating. Participation was entirely voluntary, and respondents were assured that they could withdraw from the study at any stage without any penalty. All data collected was treated with strict confidentiality and used solely for academic and research purposes. Personal identifiers were not recorded to ensure the anonymity and privacy of the participants.

Data analysis: The collected data were analyse using descriptive statistics to determine the distribution of responses and identify trends in awareness, perception, and acceptance of MSR tiles among respondents. To assess the significance of differences between groups and relationships among variables, One-way Analysis of Variance (ANOVA) and Chi-square (χ^2) tests were employed where appropriate. All statistical analyses were conducted using IBM SPSS Statistics version 25, and statistical significance was considered at $p<0.05$.

RESULTS AND DISCUSSION

Demographics: Figure 1 reveals that the majority of respondents are male (53.13%), with 46.87% being female. They are concerned about the environmental impact of the residue. The majority of workers are youths, with 21.88% having no formal education, 46.87% having secondary education, and 31.25% having tertiary education. The majority of workers are married, with 46.87% being married. The results aligned with Wan *et al.*[14] active age range of 25-54 years in Nigerian service.

Awareness and perception: The majority of respondents are aware of residue management, with 69% being aware, while 31%, are concerned about the impact of residue generated in certain areas in Fig. 2. This awareness is largely due to higher education levels, indicating sufficient government exposure to public knowledge. This aligns with Caldas *et al.*[15] that Nigeria's factors contributing to residue generation growth include population growth, urbanization, and industrialization. Despite numerous guidelines, the country faces an urgent environmental problem in managing solid waste, as it is the highest solid waste producer.

Willingness to use recycled MSR tiles: The outcome of the perception of the use of MSR for walkway tiles is illustrated in Fig. 3, as the percentage level of respondents who perceived MSR walkway tiles is 78 and 22%, respectively. This is because their perception of walkway tiles made from Municipal Solid Residue (MSR) is influenced by various factors, including their quality, appearance, sustainability, and experiences. A high percentage of respondents expressed willingness to use MSR tiles for walkway applications and readiness to purchase them if available, indicating a high acceptance of tiles made from MSR through recycled techniques[16]. However, the recycling rate is low due to insufficient facilities and a lack of economic drivers. To improve public convenience and participation in recycling activities, more facilities should be established, while 90% agree that MSR can serve as raw materials for other production, largely due to the wealth of knowledge and information available. Recycling plastic is important for conserving natural resources and protecting the environment, as it reduces the amount of fossil fuel needed to produce commodities. This is in line with Hoornweg and Bhada-Tata[16], that modern landfills

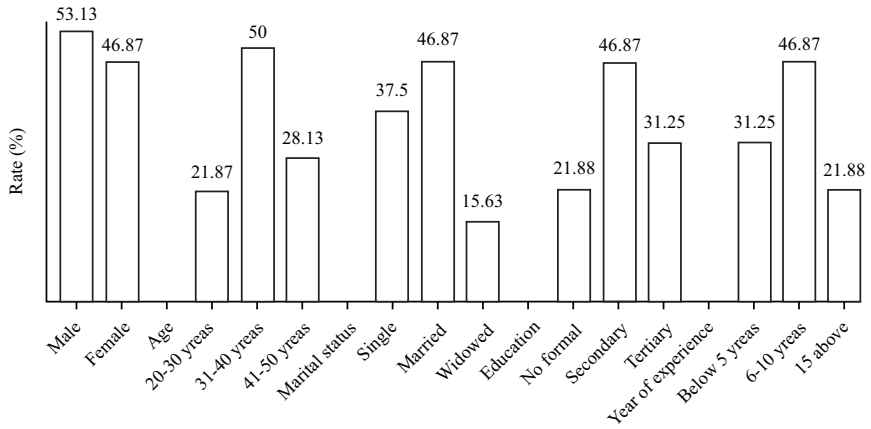

Fig. 1: Biodata of the respondents

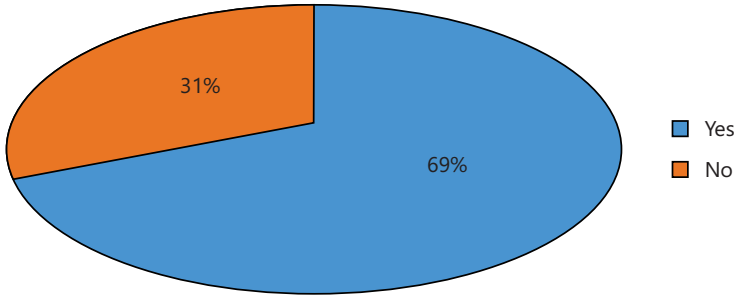

Fig. 2: MSR awareness and perception for tile production

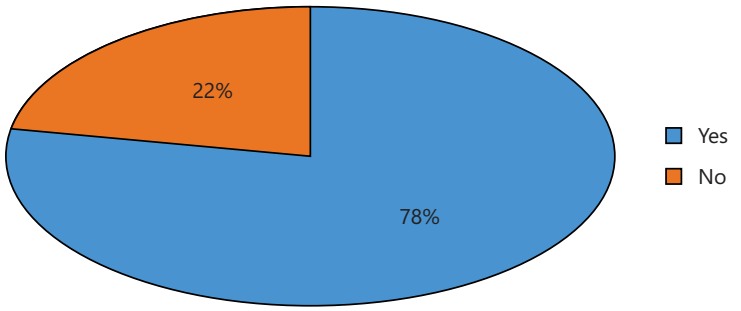

Fig. 3: Willingness to use recycled MSR tiles

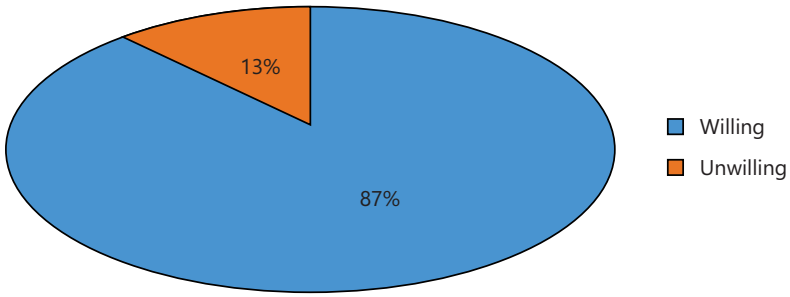

Fig. 4: Acceptability of the tiles made from MSR for walkway application

isolate residue from the environment, with local raw materials extraction having significant environmental and health impacts on low-income populations. Rapid urbanization and population growth necessitate the growth of municipal solid waste (MSR), which can be used to produce construction materials with or without pre-treatment. The use of MSR in the circular economy can help mitigate environmental injustice and promote urban sustainability.

Acceptability of MSR for walkway tiles: The acceptability of MSR for walkway tiles is high, as presented in Fig. 4, the respondents level of willingness to pay for the MSR walkway tiles is extremely high at 87.00 %, which implies that most of the workers and people are willing to use tiles made from MSR for walkway application. Wood residues can be a potential resource for creating new materials, and this willingness may be attributed to cost-effectiveness compared to other materials. This was by Macheca *et al.*[17] that sustainability is a key factor, as MSR repurposes residue materials, reducing landfill residue, the aesthetic appeal of the tiles is crucial, as well as their durability is also important, as the tiles should provide a secure walking surface with compliance to local regulations and standards which are crucial for sustainability and durability. MSR-made tiles acceptability depends on their quality, environmental benefits, long-term performance, and availability, making them highly desirable for walkway tiles.

Table 1: Awareness of MSR recycles

Response	Frequency	Percentage (%)
Important role	32	100
Little role	-	-
No role	-	-
Total	32	100

Fieldwork: 2023

Table 2: Correlation Matrix of respondents willing to pay for MSR walkway tiles

	Willing to pay	Yes	No
Willingness to pay for	1		
Walkway tiles	0.920**	1	
Made from MSR	-0.039	-0.344	1

**significant ($p<0.05$)

What role does finance play in residue management?: Table 1 shows that all the respondents agreed that finance plays a significant role in residue management, and the respondents were able to carry out their functions effectively because it is endowed with some resources. It was also revealed that finance plays a crucial role in residue management, as respondents are well-equipped with administrative and financial resources. However, the presence of these resources in the right proportion is essential for effective management. Finance is often referred to as "the sinew of war" for functional organizations in any economy. Pacheco-Torgal[18] highlights that finance is prioritized in Local Government planning for expansion and innovation for effective management.

Correlation matrix of respondents willingness to pay for msr walkway tiles: Table 2 shows that there is a significant ($p<0.05$) correlation between average residue generated and sawdusts, and also shows that there is a significant ($p<0.05$) correlation between average respondents in their willingness to pay for an eco-friendly product made from MSR. The study explores the willingness of respondents to pay for walkway tiles made from municipal solid residues (MSR). Results show a strong positive correlation between willingness to pay and general willingness to pay, a weak negative correlation between willingness to pay and non-willingness, and a moderate negative correlation between willingness to pay and non-willingness. This suggested a potential market for sustainable construction materials and highlights the need for policy support and educational initiatives.

The study on walkway tiles made from municipal solid residues (MSR) reveals the potential of these materials to contribute significantly to environmental management and sustainable construction practices. The findings reveal a high level of awareness among respondents regarding the recycling of MSR for other products, which is crucial for promoting sustainable residue management practices. By diverting MSR from landfills and repurposing it into walkway tiles, the environmental burden associated with residue disposal can be significantly reduced[8,12]. An overwhelming 87% of respondents expressed willingness to use MSR walkway tiles and purchase them if available, indicating strong market potential and consumer acceptance of eco-friendly construction materials. Functional and aesthetic value of MSR tiles were appreciated by 28% of respondents, while 9% valued their appeal. These functional benefits make MSR tiles a competitive alternative to conventional materials like concrete and ceramic, which are more resource-intensive and have higher carbon footprints. A significant 63% of respondents perceived that MSR walkway tiles have a positive environmental impact, which is critical for the adoption and acceptance of recycled materials in construction.

CONCLUSION

The study shows a strong positive perception of recycling municipal solid residues (MSR) for walkway tiles among OYSME workers, suggesting that MSR tiles could be a sustainable construction material. However, the study emphasizes the need for continued education and policy support to maximize the potential of MSR in reducing environmental pollution and promoting resource efficiency. The MSR tiles can be a

promising eco-friendly and sustainable approach to construction materials, but challenges such as technological barriers and regulatory and policy support need to be addressed. Developing efficient technologies and implementing stringent residue management rules are crucial for overcoming these barriers and promoting sustainable practices. The use of MSR tiles aligns with global efforts to promote sustainable development and reduce the construction industry's ecological footprint.

SIGNIFICANCE STATEMENT

This study focuses on the creative use of municipal solid waste in the creation of walkway tiles, which provides a sustainable solution to waste management issues. By transforming solid waste into value-added construction materials, the study promotes environmental conservation, minimizes landfill load, and helps to produce eco-friendly infrastructure. The findings show that garbage recycling may be integrated into urban development initiatives, helping to clean up cities and advance circular economy principles.

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