PRODUCTION OF ECO-FRIENDLY COMPOSITE TILES FOR BUILDING APPLICATIONS FROM RECYCLED PLASTIC WASTE

A PROPOSAL

SUBMITTED TO

NATIONAL AGENCY FOR SCIENCE AND ENGINEERING INFRASTRUCTURE (NASENI)
GARKI, ABUJA

BY

JOCK ASANJA ALEXANDER (PRINCIPAL INVESTIGATOR)

DEPARTMENT OF CHEMICAL ENGINEERING,
FEDERAL UNIVERSITY WUKARI, WUKARI, TARABA STATE, NIGERIA

OCTOBER, 2025

EXECUTIVE SUMMARY

Plastic waste has become a major global subject of discussion due to its connectedness to factors like population growth, urbanization, industrialization, and lifestyle change. Plastics due to their versatile nature are being widely employed in human lives. With the increasing use of plastics in different commercial applications they make up a fundamental part of our everyday lives. The extensive use of plastic in households, industries, construction, automobiles, packaging and construction significantly increases the production and the spread of plastic waste. Despite its convenience, durability, and versatility, plastic disposal poses severe environmental challenges, such as pollution, habitat disruption, and landfill overcrowding.

Plastics are made from synthetic materials, primarily derived from petrochemicals, and often contain additives to enhance their properties. Their non-biodegradability raises significant environmental concerns. Developing countries, like Nigeria and others, face major environmental and public health challenges due to inadequate waste management and poor recycling infrastructure. It is important to note that waste plastics are easily accessible materials in addition to the fact that they have other valuable economic relevance. For example, waste plastics can be reused to make tiles and the tiles are used in flooring houses, making terraces and bathrooms and so on and so forth.

This research supports the idea of sustainability and a circular economy via the utilization of waste to produce value-added products. The research explored the likely potentials that can be derived from the use of plastic waste as a raw material for the manufacturing of tiles as an alternative to the conventional ceramic tiles available in the markets. The main focus is to enhance the management of plastic waste and to highlight reusing plastic waste through recycling in a comparatively less capital intensive manner by development of bio-friendly polymer tiles from heterogeneous non-degradable plastic wastes via the use of pyro technique process and characterization of the properties of polymer tiles. The research is estimated at the cost of **fifteen million, three hundred and thirty thousand naira (15,430,000) only.**

1.0 INTRODUCTION

Human activities often and generally generate solid waste that included plastic waste. The management of plastic wastes are now a global problem that requires urgent attention and this is relevant in order to address or solve worldwide problems concerning resources and energy. Plastic is one of the integral components of our daily life and being responsible for polluting the environment once it is thrown away after use. In recent years, the use of plastics has increased manifolds resulting to the accumulation of plastic waste in large quantities. The usages of plastic products are interconnected to other factors that are leading to polluting the environment. The increasing plastic waste causes a lot of threat to the environment and even repeated recycling pose a potential danger. The disposal of this waste is usually a setback. Different types of plastics which are widely used are thermoplastics and thermo-setting plastics. Among these, thermoplastics can be easily and cheaply molded and re-molded to different usable forms. Generally, plastics are used in many ways such as toys, plastic bags, tables, television boxes, Water bottles, etc. (Kadam and Sonawane, 2021).

Plastics are a generic group of synthetic or natural materials consisting of high molecular-weight chains composed predominantly if not entirely of carbon. The amount of plastic waste generated in developing nations like Nigeria is increasing day by day, which is non-biodegradable and causes environmental pollution. Among the plastics used, low-density polyethylene is abundant. These plastics can be removed from the environment and recycled into useful products (Jock *et al.* 2022).

Production of plastic has leveled off in recent years, however, it is not declining and may well increase in the future as applications for plastic increase and its use continues to grow in developing and emerging economies. Without appropriate waste management, this will lead to increased plastic waste, which will add to the 'back log' of plastic waste already in existence (Mohammed *et al.* 2023).

As demand for materials with certain qualities increases, the plastics industry will aim to supply them. Meanwhile, increasing plastic production and use in emerging economies looks set to continue, and waste management infrastructure will have to develop accordingly. Traditional disposal methods like incineration and landfilling are criticized for their environmental and health impacts. Many researchers have focused their attention on finding suitable methods for recycling and re-utilization of plastic waste material in an economically and environmentally viable. Therefore, it has been attempted to explore various ways to find an alternative and easy way to reuse the plastic waste in a useful manner to improve the sustainability of the environment. Repurposing plastic waste into tiles for pedestrian walkways, parking lots, and other applications offers a sustainable solution. These tiles showcase the potential of plastic waste recycling, contributing to sustainable waste management practices and promoting a circular economy. Converting plastic waste into valuable products like tiles provides an innovative solution. This study aims to explore additional innovative ways for converting plastic waste into high-quality tiles, investigate the mechanical and physical properties of these tiles, and evaluate the environmental and economic benefits, contributing to a more sustainable and eco-friendly approach to waste management.

1.1 PROBLEM STATEMENT/JUSTIFICATION

The world is grappling with an unprecedented plastic waste crisis. Despite increased awareness and recycling efforts, only about 9% of all plastic waste ever produced has been recycled. The remainder accumulates in landfills or the natural environment, causing severe ecological damage. The environmental impact of plastic waste is particularly severe in waterways and coastal regions, causing blockages, flooding, and marine pollution.

The improper disposal of these waste plastics after use such as burning in open air is a major source of air pollution. Since it releases dioxins, furans, mercury, and polychlorinated biphenyl into the atmosphere. Also, burning of polyvinylchloride liberates hazardous halogens and pollutes the air and the impact is climate change and diseases. The toxic substances that are released are posing threats to vegetation, human and animal health and also the environment as a whole. Burning of waste plastic is a serious health concern because smoke from the fire emits black carbon and other particulate matter emission which can have a significant impact on health causing respiratory problems, health diseases and brain cancer. Waste plastics when burnt causes air pollution which release toxins such as chlorine and bromine that destroys ozone layers which in turn leads to global warming. Our study is aimed at overcoming these limitations by developing a process that can utilize a wide range of plastic waste to produce a high-value end product.

JUSTIFICATION

The role of plastic materials in human lives cannot be over emphasized ranging from use as household appliances, packaging materials and many more which are widely used in our communities. The construction industry faces mounting pressure to adopt more sustainable practices and materials. Traditional tile production from ceramic materials, often relying on energy-intensive processes. However, converting plastic waste into durable, attractive tiles for construction use will drastically reduce the volume of plastic entering landfills and ecosystems decrease the demand for virgin materials in tile production and create a new market for recycled materials or better waste management. All these legion of problems posed by this improper disposal of waste plastics triggered the research focused on converting waste plastics into innovative composite tiles thereby providing affordable and durable building materials for developing nations. This could also pave the way for a new paradigm in waste management and sustainable construction, contributing to global efforts in combating plastic pollution and climate change.

1.2 AIM AND OBJECTIVES

The aim of this research is to develop durable and cost-effective composite building construction tiles from plastic waste materials. The aim will be achieved through the following objectives;

i. determining the suitability of plastic waste in the development of plastic tiles
ii. developing a process and model of convert various types of plastic waste into high-quality tiles
iii. Formulating and producing tiles from heterogeneous plastic waste materials
iv. Characterizing the produced plastic tiles for physical, mechanical and chemical properties
v. Conduct cost analysis and economic viability for converting waste plastic to tiles

2.0 LITERATURE REVIEW

Population growth and rising living standards as a result of technological advances have contributed to An increase in the amount of solid waste produced by industry, mining, and domestic and agricultural activities. Modern life cannot be imagined without plastic as they are found everywhere like toys, television sets, water bottles, cell phones, etc. The waste generated by plastic is huge while their disposal is problematic (Jadhav *et al.* 2022).

Global plastic consumption has surged from 5 million tons in the 1950s to over 450 million tons in 2000s due to economic growth and changing consumption patterns. Plastic waste comprises 8–12% of the municipal waste stream, and approximately 190 million tonnes are generated yearly. Millions of tons of plastic waste enter the oceans annually, with estimates of 4.8 to 12.7 million tons dumped in 2014 alone. Comprehensive solutions like waste reduction, recycling, and alternative materials are necessary to address this issue (Ronkay *et al.* 2021).

Plastic waste is considered one of the significant environmental problems due to its hazardous effects and difficulty of disposal. Their non-biodegradability raises significant environmental concerns. Factors such as population growth, low production costs, wide varieties, and applications result in an increased production of plastics. As a result, a large quantity of plastic is discarded, and only a fractional part of it is recycled; thus, the effective management of plastic waste remains a global challenge for both developed and developing countries. The traditional approach of managing plastic waste as a landfill is unsustainable and has given the scarcity of land in urban precincts. The disposal of plastic waste into landfills leads to remain locking up of valuable resources (Soni *et al*. 2022).

Plastics are made from synthetic materials, primarily derived from petrochemicals, and often contain additives to enhance their properties. Plastics can refer to materials comprising several elements: carbon, nitrogen, oxygen, hydrogen, chlorine, and sulphur. Plastics are formed through polymerization, which can be either condensation or addition polymerization. Based on their physical properties, plastics can be classified either as thermosetting or thermoplastics plastic materials. Thermoplastic materials are plastic that can be formed into desired shapes under heat and pressure and become solid on cooling. In contrast, thermosetting plastics materials, once shaped, cannot be remoulded by applying heat. Some of the difficulties linked with improper disposal of plastic waste include littering landscapes, polluting beaches and oceans, the generation of toxic fumes when burnt, and bags made up of plastics killing animals (Ikri and Okpoko, 2022).

The wastes plastic in household is large and increases with time. In each country the waste composition is different, since it is affected by socioeconomic characteristics, consumption patterns and waste management programs, but generally the level of plastics in waste composition is high. The largest component of the plastic waste is polyethylene, followed by polypropylene, polyethylene terepthalate and polystyrene (Puttaraj *et. al.* 2020). It is estimated that the plastic waste will double after a decade as we use hundred grades of plastic in our daily life. We can recycle, reuse the plastic waste. Application of Plastic Tiles includes for parking floors, footpath way, in bathroom and gardens for good aesthetic view (Somwanshi *et al.* 2021).

Plastic wastes have various ways to turn it to the useful products. Such as recycling of plastic waste into tiles with reduced flammability and improved tensile strength has been investigated with extensive results. A review study was conducted to investigate the use of recycled solid waste materials in asphalt pavements. On the hand, the analysis of tiles made from recyclable LDPE plastic waste has been carried out to illustrate the manufacturing of tiles and bricks from LDPE, low-density polyethylene, plastic waste (Uddin *et al.* 2023).

The successful recycling of waste plastic for developing new materials would significantly improve the environmental conditions and reduce the demand for virgin quarry materials. The polymer-based composite is applied to building construction materials such as floor tiles and pavements. The research demonstrates the development of eco-friendly thermoplastic composite materials like floor tiles. It saves and sustains natural resources which can't be replenished, decreases environmental pollution, saves energy and reduces the requirement for fresh raw materials for building materials. The development of an effective recycling method is considered one of the most urgent requirements to overcome the burden of plastic waste around the globe. The waste plastics are being used as a matrix for developing polymer-based composites found in building construction materials to improve the recycling practice. However, the workability of such a composite is unexplored. Moreover, there is a shortage of available data for the characteristics of plastic-sand composites and their responses to the given properties. Despite their great potential, this research gap has hampered the application of polymeric composites to a wide range of building construction materials. This proposal outlines an innovative project to develop durable and cost-effective tiles from plastic waste. By repurposing plastic waste into functional construction materials, we believe that this study will address the global plastic waste crisis, explore the suitability of the polymer-based composite materials and the need for sustainable building construction.

.

3.0 METHODOLOGY

The steps involved in the production of the prototype of composite floor/wall tiles are detailed as follows:

3.1 Collection of raw materials

Important grades of plastic materials such as polyethylene are high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE) and low-density polyethylene (LDPE) will be collected from various locations within Federal University Wukari premises and environment where large volume of plastic wastes is generated and where most times these wastes are burnt openly thereby contaminating the air we breathe.

3.2 Sorting, washing and drying

This involves the separation of the plastic materials according to types (manual identification) like LDPE, LLDPE, HDPE, PET, etc. and developing protocols for removing contaminants and non-plastic materials. Liquid soap, water and disinfectant will be used to wash the plastics and allowed to dry. The reason for washing is to remove any label attached to the bottles, dust, adhesives and other impurities in the plastic materials. Then, followed by sun drying

3.3 Shredding of plastic materials

Shredding will be carried out to reduce plastic waste into small pieces for easy melting. The shredded plastic waste will further be washed and dried to remove contaminants.

3.4 Collection and sieving of reinforcement materials

Reinforcement materials such as clay-free fine sand, fly ash, stones, marbles, cement, etc. will be collected from various sources, dried, pulverized and sieved through 125 µm mesh size. The fine power will serve as the loose particles or filler in the mixing process so as to give a fine surface finishing and strength in the final product.

3.5 Formulation of floor tiles

The required amount of the shredded plastic waste and reinforcement materials for tiles production will be weighed using a digital weighing balance.

3.6 Mixing and Melting of the tiles formulated materials

This is a physical process that results in the phase transition of a substance from a solid to liquid. This occurs when the internal energy of the solid increases, typically by application of heat which increases the plastic temperature to the melting point. At the melting point the ordering of ions or molecules in the solid breaks down to a less ordered state melts to become liquid. This process is carried out after placing the shredded plastic waste in a pyrolysis reactor and allowed to melt completely. The weighed reinforcement materials will be added to the melted plastic and the mixture is stirred thoroughly to allow uniformity and achieve smooth consistency.

3.7 Moulding, curing and Solidification

The melted plastic and reinforcement materials will be poured into metallic stainless tile moulds of various sizes and designs coated with lubricating oil to facilitate demoulding. The mixture in the mould will be compressed by applying pressure to ensure uniformity and remove air bubbles that can cause crack on the composite. The cooling of the finished product (floor/wall tiles) will be controlled to prevent warping and ensure structural integrity. This will be done by deeping the mould and its content into a basin of water and allowed to solidify for 5 minutes.

3.8 Solidification and Demoulding

This process involves allowing the tiles product in the mould to stay overnight in other to acquired more strength and to ease surface treatment. The tile will then be removed from the mould for characterization.

3.9 Product characterization

The evaluation of properties is important for identifying the performance of the developed products and establishing their workability. The tile samples will be characterized for chemical, physical, and mechanical properties such as water absorption, compressive strength, fexural strength, hardness, coefcient of friction, and sliding wear rate. Others are transverse resistance, resistance of impact and abrasion resistance tests, tribological and morphological analysis will also be conducted.

4.0 EXPECTED OUTCOMES AND PRACTICAL APPLICATION

This research is expected to:

i. Develop durable and cost-effective a range of tile prototypes varying in size, thickness, and design.

ii. Document optimal processing parameters for different plastic types conversion.

iii. Generate comprehensive data set comparing plastic tiles to traditional materials across key metrics

iv. Establishment of a new sector in the circular economy through revolutionize waste management and the construction industry

5.0 BUDGET

S/N	ITEM	DESCRIPTION	UNIT COST (N)	TOTAL COST(N)
1.0	**Raw materials collection/purchase**			
	i. Plastic waste	Variety of thermo plastic waste materials from different locations.		100,000
	ii. Reinforcement materials	Collection and purchase materials such as fine sand, fly ash, marble, rocks, cement, etc.		150,000
	Sub-Total			250,000
2.0	**Sample Purification/Preparation**			
	i. Cleaning/washing and drying	Sorted plastic waste	150,000	150,000
	ii. Sieving of reinforcement materials and shredding of plastic waste	Crushing/shredding of plastic waste materials and sieving of fine sand, fly ash	250,000	250,000
	Sub-Total			400,000
3.0	**Equipment**			
	Shredder	Reduce plastic waste to uniform small pieces	1,500,000	1,500,000
	Washer	Wash shredded plastic to remove impurities	1,200,000	1,200,000
	Melter (Pyrolysis reactor)	To melt plastic at controlled without degradation	4,500,000	4,500,000
	Mixer	To blend different plastic types and reinforcing materials	2,000,000	2,000,000
	Sub-Total			9,200,000
4.0	**Supplies/Consumables**			
	i. Stainless steel moulds	Various sizes	25,000	250,000
	ii. Trowel	Metallic plate	50,000	100,000
	iii. Lubricating oil	10 Litre	5,000	50,000
	iv. Metal bucket	25 Litre	10,000	50,000
	v. Plastic bucket	100 Litre	15,000	45,000
	vi. Safety goggles		10,000	40,000
	iv. Hand gloves		15,000	60,000
	v. Safety boots		25,000	100,000
	Sub-Total			695,000
5.0	**Characterization**			
5.1	Raw materials (plastic waste, fine sand, fly ash, cement,)			
		X-ray Fluorescence (XRF)	15,000	75,000

		X-ray Diffraction (XRD)	20,000	100,000
		Scanning Electron Microscopy (SEM)	10,000	50,000
		Fourier Transform Infrared (FTIR) spectroscopy	10,000	50,000
		Brunauer, Emmett Teller (BET)	25,000	125,000
		Gas chromatograph-mass spectroscopy (GCMS)	15,000	75,000
5.3	Finished Product Analysis			
	i. Structural integrity			
		a. Compressive strength	10,000	100,000
		b. Flexural strength	5,000	50,000
		c. Coefficient of friction	5,000	50,000
		d. Water absorption	5,000	50,000
		e. Density	2,000	20,000
	ii. Durability Test			
		a. Resistance to wear	10,000	100,000
		b. Hardness	5,000	50,000
		c. Impact resistance	10,000	100,000
		d. Abrasion resistance	7,000	70,000
		e. Transverse resistance	10,000	10,000
		f. Tribological	15,000	150,000
		g. Morphological	10,000	100,000
	iii. Chemical analysis			
		a. Leaching	5,000	50,000
		b. Off-gassing	8,000	80,000
	iv. Environmental and safety			
		a. Fire resistance	10,000	100,000
		b. Weather resistance	15,000	150,000
		c. Slip resistance	10,000	100,000
		d. Lifecycle analysis	20,000	200,000
	Sub-Total			2,005,000
6.0	**Travels**			
		Raw material collection/Purchase		150,000
		Transport, round trip for taking samples for characterization		100,000
		Accommodation and feeding	60,000/day	180,000
	Sub-Total			430,000
7.0	**Others/Miscellaneous**			
		Internet/Data for browsing		200,000
		Contacts/visits/consultations		100,000
		Fuels for running generator set		150,000
		Allowances for adhoc staff		500,000

	Sub-Total			950,000
	Personal costs/Allowances			
	Principal Researcher			300,000
	Team Members (4x)		240,000	960,000
	Technical Support (2x)		120,000	240,000
	Sub-Total			1,500,000
	Grand Total			**15,430,000**

6.0 RESEACH SCHEDULE

S/N	ACTIVITIES	MONTHS											
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
1	Literature review and detailed project planning												
2	Establishment of partnerships for waste collection												
3	Set up of processing and testing equipment												
4	Development and optimization of waste sorting protocols												
5	initial experiments with plastic melting and molding techniques												
6	Production of first tile prototypes												
7	Characterization of the finished product												
8	Refinement of production process based on initial results												
9	Scale-up of production level												
10	Tabulation and discussion of results												
11	Compilation of research report and submission												

REFERENCES

Ikri, O.S. and Okpoko, S.J. (2022). The Effects of Plastic Waste Materials on the Physical and Strength Properties of Floor Tiles, *International Journal of Emerging Scientific Research*, 3: 13-22

Jadhav, S., Sangale, R., Gupta, S., Patil, P., Vaidya, R. (2022). Making Of Economical Plastic Tiles Using Plastic Waste, *International Research Journal of Engineering and Technology*, 09(6): 412-414

Jock, A. A., Akpan, M.L. and Oluwadayo, A.F. (2022). Production and Characterization of Sand-Plastic Composite Floor Tiles. *Hungarian Journal of Industry and Chemistry.*30-33

Kadam, A.A. and Sonawane, A. (2021). Production of Plastic Tiles and its Testing, *International Research Journal of Modernization in Engineering Technology and Science*, 3(5): 966-969

Mohammed, O., Ogah, A.T. and Mahnoud, A. (2023).Recycling and Processing Of Plastic Waste into Plastic Tile a Step towards Sustainability in Abuja Municipal Area Council Federal Capital Territory, Nigeria, *Journal of Research in Humanities and Social Science,* 11(1): 317-325

Puttaraj, M. H., Parangi, B., Gagan, M. S., Shivu, S. Hallur, M.S. (2020). Reuse of plastics waste for the production of floor tiles, *Journal of Seybold Report*, 15(8): 1633- 1639

Ronkay, F., Molnar, B., Gere, D., & Czigany, T. (2021). Plastic waste from marine environment: Demonstration of possible routes for recycling by different manufacturing technologies. *Waste Management*, *119*, 101-110.

Somwanshi, R., Bagdiya, N. and Chipade, A. (2021). Overview on Manufacturing of Tiles from Plastic Waste, *International Journal for Research in Applied Science & Engineering Technology,* 9(6): 4978- 4981

Soni, A., Das, P.K., Yusuf, M., Kamyab, H. and Chelliapan, S. (2022). Development of sand- plastic composites as foor tiles using silica sand and recycled thermoplastics: a sustainable approach for cleaner production, *Scientifc Reports,* 12: 1-19

Uddin, M.S., Abedin, M.Z. and Ali, M.Y. (2023). Fabrication and Characterization of Plastic Tiles from Plastic Wastes in Bangladesh, *AIP Conference Proceedings 2643*, 1-9

RESEARCH TEAM MEMBERS

S/No	Name	Rank	Highest Qualification	Area of Specialization	Telephone and Email
1	Alexander Jock - Principal Investigator	Associate Professor	PhD	Biochemical and Environmental Engineering	jockasanja@fuwukari.edu.ng +234 8036055325
2	Caleb Popoola- Member	Associate Professor	PhD	Production Engineering	popoola@fuwukari.edu.ng +234 8141129310
3	Thaddeus Julius- Member	Senior Lecturer	PhD	Mechanical Engineering	thaddeus.julius@fuwukari.edu.ng +2347039366748
4	Haruna Amani-Member	Lecturer I	M.SC	Environmental and Process Engineering	amani@fuwukari.edu.ng +2348039255757
5	Ms. Mazi Clare-Member	Principal Technologist	M.Eng.	Polymer Engineering	claremazi@fuwukari.edu.ng +234 8032347293