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PRODUCTION OF COMPOSITE FLOOR TILES USING PLASTIC WASTE AND WOOD DUST

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ABSTRACT

The role of plastics in human lives cannot be over emphasized. It is used as household appliances, packaging materials, potable water and beverage containers, kitchen utensils, furniture, toys, automobile parts, polythene bags etc (Abota, 2012). The great attention given to the use of plastics is attributed to their generally light, cheap and durability nature and this account for their preference over other materials (Hopewell *et al*, 2009). The negative effects associated with the increase in uses of plastics include blockage of drains, ground impermeability to water, hazard to animal health due to accidental ingestion of plastic waste etc. The expanding population and increased preference for packaged commodities are worsening the negative environmental impacts of these plastics (Kalilu, 2013). The need therefore arises to find safe methods of converting plastic waste into other useful and harmless products. Wood dust, a by-product of wood which also presents a number of health and safety hazards can be used in conjunction with plastic waste to make a number of useful products. The method adopted in this work involved collecting plastic waste materials from trenches and drainages around Benin metropolis in Edo state, Nigeria. The plastics were sorted, washed, dried and shredded into smaller particles and thereafter kept in plastic bags for further use. Wood dust was also collected from a sawmill in Benin city, ovendried and sieved into fine powder. The composite tiles were produced by first melting the shredded plastics in a pressure pot placed on a heat source. The wood dust was then added to the plastic melt with continuous stirring until a homogenous mix was attained. The mixture was poured into a fabricated metal mould (dimension: 12cm x 10cm x 4cm), covered and allowed to solidify and cure for 5 days after which the product was removed from the mould and subjected to various mechanical and chemical test to determine and Compare its properties

with that of conventional ceramic tiles.From the Mechanical tests results, the composite tiles failed under load of 39 kN while the conventional tiles, 36 kN. Cold and hot water has no effect on both the composite and conventional tiles respectively. For flammability test, scorched surface and deformation in shape was observed for the composite tiles while the conventional tiles splitted under the influence of flame. From the chemical test results, it was observed that both the composite and conventional ceramic tiles were not affected by petrol, kerosene, diesel, toluene, engine oil, acetone, KOH solution and dilute HCl.

Keywords: *Plastic Waste; Wood Dust; Composite; Tiles; Recycling.*

INTRODUCTION

Plastics are synthetic, semi-synthetic ornon-synthetic materials which are polymeric and are composed of large molecules of organic substances known as monomers (Hazzan, 2003).They are similar in many ways to natural resins found in trees and otherplants (https://plastics.americanchemistry.com).Pure water sachets and bottles are products of plastics which are used widely in Nigeria for various purposes, such as packaging of pure potable water, soft drinks etc. This when not properly disposed after consuming its content can pose a great environmental problem. Empty polythene plastic containers are rampant in the nook and cranny of the Nigerian landscape. These Plastic materials are non-biodegradable and when they find their way into the soil prevents water percolation, restriction of plants roots from stretching and getting the required amount of water for growth. They also hinder the exchange of gases for respiration by plants and animals in the water bodies. Some of these wastes that litter the streets find their ways into drains, trenches and canals, thereby clogging drains and hindering the free flow of water and consequently leading to flooding (Sharma, 2008). This menace caused by pure water sachets and plastic bottles is very obvious during or immediately after rains in urban areas, where drainage channels conveniently serve as the dumping sites for these plastic wastes (plate 1).

Plate 1: plastic waste in drainage channels after rain in Uselu Lagos road, Benin city
Source: Author

These non-biodegradable thermoplastic materials used for commodity goods storage and packaging purposes accounts for over 60 million tons of annual wastes generation worldwide (Justo and Veeraragavan, 2002). It was also reported (Aremu, 2009) that 30% of the domestic waste in a typical Nigerian city comprises of the polythene and plastic products in very large quantities; whose disposal has continued to constitute the great environmental pollution challenge and concern in big and small cities.
On the other hand, wood dust, a by-product of wood processing is a known human carcinogen which presents a number of health and safety hazards (www.statefundca.com). Certain woods and their dust contain toxins that can produce severe allergic reactions when inhaled. Wood dust is flammable and accumulations provide a ready source of fuel. Airborne wood dust can be ignited by sparks or even heat accumulation and result in explosions. Wood dust may collect in piles and add harmful leachates into local water systems, creating an environmental hazard. (https://en.wikipedia.org/wiki/Sawdust#cite).

In view of all the hazards that accompany the improper disposal, the need then arises to find a safe means of converting these plastic and wood waste products into other useful and harmless items. A consideration of processing these waste materials by recycling to other beneficial products, can contribute more positively to material cost reduction; health, safety and environmental sanitation. Recycling is an economic development tool

as well as an environmental tool. This research work therefore focuses on the use of thermoplastic waste materials and wood dust for the production of composite floor tiles which can possibly serve as a substitute for conventional floor tiles.

MATERIALS AND METHODS

Collection and preparation of plastic waste materials

Plastic waste materials (pure water satchets and bottles) were collected from trenches, drainages, streets and dump sites around Benin metropolis, Edo state, Nigeria. Sortingwas done manually by separating the plastic materials into categories according to the Plastic Identification Code (PIC). The sorted plastic materials were washed using water and detergent to remove attached labels on bottles and to get rid of contaminants such as adhesives and dirt; and thereafter allowed to dry. This was followed by manual shredding of the sorted, washed and dried plastic materials using knives, hand saws and scissors.

Collection and preparation of wood dust and sieving operation

Wood dust was collected during wood milling operation of Mahogany from a sawmill in Benin city. It was oven dried at 80^{o}C to attain a constant weight and thereafter sieved through 35 mesh to obtain fine particles which was used to provide the fine surface finishing of the composite.

Production of composite

A pressure pot was placed on a heat source (gas cooker) and allowed to heat up for 3 minutes. 100 g of the shredded water sachet and 300 g of PET plastic waste bottles were weighed into the hot pot and allowed to melt completely inside the pot while stirring with a wooden spatula. 100 g of the finely sieved oven-dried wood dust was then added to the plastic melt with continuous stirring to attain a homogenous mixture. This was then poured into a fabricated metal mould of dimension, 12cm x10cm x 4cm which had been lubricated with paraffin oil to facilitate removal of product after solidification. The edges of the mould were gently banged on the floor to allow for even spreading of the molten material as well as aids the escape of bubbles that are capable of causing voids and cracks in the composite. The mould was covered with its lid and the composite material allowed to cool, solidify and cure for 5 days before removal from the mould (plate 2).

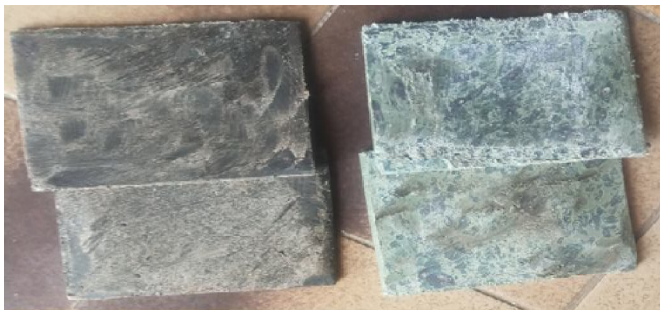

plate 2: Composite tiles produced from the recycled plastic materials.
Source: Author

Laboratory tests

Chemical and mechanical Tests were carried out on the composite tiles to ascertain their suitability for floor and wall tiling and compared with conventional ceramic tiles. These tests include acid, alkali, and solvents resistance test, water absorption, crushing, frictional coefficient and flammability tests.

Chemical test

The chemicals used for this test include hydrochloric acid, sodiumhydroxide, and some solvents. The tests were carried out to determine the resistance of the samples to such chemicals.

Acid and alkali solutions test

Dilute solutions of hydrochloric acid and potassium hydroxide were prepared respectively in small test bottles. Small pieces of the samples (composite and conventional) were cut and immersed in the solutions respectively for 7 days to find out their level of resistance to the chemicals. Observations were made and results were recorded.

Solvents resistance test

Solvents used in this test include petrol, engine oil, diesel, kerosene, toluene and acetone. The test samples were cut into small sizes and immersed in the different solvents respectively for 7 days after which they were removed and observations made and recorded.

Water absorption test (Cold and hot water)

The cold water absorption test involved weighing the composite and conventional tile before and after immersion in water at room temperature using a laboratory weighing scale of capacity of 5 kg. Duration of immersion was 30 minutes and the weights obtained were recorded.

The hot water absorption test also involved weighing the composite and conventional tiles samples using the weighing scale and thereafter immersing them into boiling water for 30 minutes After which they were removed from the water and reweighed in order to obtain the quantity of water absorbed.

Crushing test

The crushing test was done using the Universal Testing Machine (U.T.M). this involved first reducing the dimension of the composite and conventional materials to 100 mm in length and breadth and a thickness of 35 mm. This was then placed in the machine and load was applied until a noticeable fracture in the composite and conventional material was observed respectively. The failure load was then obtained and recorded.

Frictional coefficient test

The frictional coefficient test is used to obtain the slip properties of the tiles. This was done by placing the composite sample on a level platform, and known masses of different materials of different surface finishing such as match box, toothpaste tube, stone, baby sandal etc. were placed one after the other on the composite. With one end of the composite in position, the opposite end was continuously raised such that the material inclines at an angle. The angle of inclination was continuously increased until the material placed on top of the composite rolled off. At this point the value of the angle of inclination was taken and recorded; this is called the angle of repose. The test was also replicated for the conventional tiles sample. The Frictional coefficient was obtained using the equation below:

Frictional coefficient μ (N/Kg) = Tan θ (1)

Flammability tests

This will reveal the flame resistant ability of the tiles, which will give an insight into the behaviour of the product in case of fire incidence. The flammability test involved placing the composite tile sample on a butane gas flame and allowed to burn, first for 5 seconds and thereafter withdrawn from the fire and observed for changes in the sample. The procedure was repeated for a duration of 2 minutes and observations were made and recorded. Conventional tile sample was also subjected to the same test for the purpose of comparison and observations were made and recorded.

RESULTS AND DISCUSSION

Chemical tests results

Results obtained from the chemical test are shown in table 1 below.

Table 1: chemical resistance test result

samples	Chemicals							
	Petrol	Engine oil	Diesel	Kerosene	Toluene	Acetone	Dil. HCl	KOH solution
Composite tile	NA	NA	NA	NA	NA	NA	NA	NA
Conventional tile	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not affected

From the chemical test result, both the composite and conventional tiles showed no change in weight, colour or texture, hence unaffected by the chemicals. Therefore, composite tiles from recycled plastic waste and wood dust is comparable in terms of these chemicals resistance to conventional ceramic tiles and can therefore be recommended as tiling material for petrol and oil stations including other environments where such chemicals are used. Solvent such as acetone, dilute HCl, toluene etc. may also be used as components of cleaning agent for the composite tiles.

Mechanical Tests Results

Results obtained from the mechanical test are shown in table 3 below. These include water absorption, crushing, frictional coefficient and flammability tests.

Water Absorption (Cold and Hot) Test Results:

This test is expected to reveal the hot and cold water absorbing capacity of the composite tiles produced from the recycled plastic and this would be compared with that of the conventional tiles. This result will help to determine whether the composite tiles are suitable as floor and wall tiles for both bathroom and kitchen.

Results from Cold and Hot Water Absorption Testing

Cold water testing: The following results were obtained for the cold water absorption test carried out:

Weight of the composite before immersion Y_c= 0.42 kg

Weight of the composite sample after cold immersion Z_c = 0.42 kg

Amount of water absorbed = Weight after immersion - weight before immersion

That is: Z_c-Y_c = 0.42-0.42 =0.00 kg.

From the results, composite tiles produced from the recycled plastic shows a zero absorbing capacity when immersed in cold water. This is comparable to the conventional ceramic tiles sold in the market, which also, is water resistant. Hence, the composite tiles produced from the recycled plastic bottles and water sachet can act as an alternative to ceramic tiles.

Hot water testing: The amount of water absorbed during the hot water absorption test was obtained as follow:

Weight of the composite before immersion Y_h= 0.42 kg

Weight of the composite sample after hot immersion Z_h = 0.42 kg

Amount of water absorbed = Weight after immersion - weight before emersion

That is: Z_h - Y_h = 0.42-0.42 = 0.00 kg.

From the calculation above, it can be observed that there was no water absorption by the composite after 30 minutes of immersion in boiling water. Also there was no crack on the composite sample tested, this show the ability of the tiles to resist heat from the boiling water.

With the above observation, it is pertinent to note that, the composite produced from recycled water sachet /plastic bottles possess the ability to resist heat from the boiling water. Hence the composite tiles can be used as floor and wall tiles for both bathroom and kitchen.

Crushing Test Results:

The value of the failure load of the composite was determined and compared with that of the conventional tiles (table 3). The result shows that the composite failed under a heavier load of 39KN as compared to the 34KN failure load of the conventional tiles. Hence, the composite tiles can be recommended as an alternative to the conventional ceramic tiles in terms of load bearing capacity. For a material to be used as floor tile it must have high load carrying capacity as people and items of various weight will be stationary or moving on the tiles. The composite tile also showed an advantage of high impact strength as it did not shatter under sudden loading. This is one major setback for the conventional ceramic tiles which will readily shatter into smaller sharp pieces under sudden load or when released from a height and these can cause serious injuries to human beings.

Flammability Tests Results (Composite and Conventional)

From the flammability test, it was noticed that after 2 minutes of heating over a butane gas flame, a scorchedsurface with deformation of shape was observed for the composite tiles when the heat source was removed. Whereas, the conventional tiles forcefully splitted into two separate pieces after 2 minutes of heating over the flame. This result therefore reveals the advantage of reusability of the composite tile since it did not split into smaller injurious pieces as in the case of the conventional tile. this is also an advantage in the case of a fire incidence as the composite tile will not cause injuries since they will not forcefully split into pieces that can pierce human skin.

Frictional coefficient test results:

This result will reveal whether the values of frictional coefficients of the composite are comparable to that of the conventional tiles. Higher frictional coefficient promotes more friction and this in turn reduces the risk of slipping on tiles which could cause injury to human beings. The different materials used for the frictional coefficient test, calculations and results are shown in table 2 below.

Results from test shows that the composite tiles possess higher frictional coefficient than the conventional tiles and this will promote more friction. Hence, the composite tiles produced from the recycled plastics can be used as home floor tiles without the fear of slipping and falling on tiles.

Table 2: frictional coefficient test results.

Material	Weight of material		Composite tiles		Conventional tiles	
	g	Kg	Angle of repose (Ø°)	Frictional coefficient (μ) N/Kg	Angle of repose (Ø°)	Frictional coefficient (μ) N/Kg
Empty paste tube	6.3	0.0063	35	0.700	30	0.577
Empty match box	2.0	0.0020	29	0.554	24	0.445
Baby comb	11.1	0.0111	30	0.577	25	0.466
Baby sandal	54.5	0.0545	60	1.732	56	1.483
Key holder	34.5	0.0365	30	0.577	25	0.466
Eraser	29.3	0.0293	40	0.839	34	0.675
Pen	6.6	0.0066	20	0.364	15	0.268
Reel of thread	5.6	0.0056 0.0947	9	0.158	4	0.070
Glass case	94.7	0.0947	40	0.839	33	0.649
Average frictional coefficient (μ)				0.704		0.567

Table 3: mechanical test results.

Mechanical Tests	Conventional Tiles	Composite Tiles
Cold Water Absorption Tests	0.00kg	0.00kg
Hot Water Absorption Tests	0.00kg	0.00kg
Crushing Test	34.00kN	39.00kN
Flammability Tests	Splits under flame	Scorched surface
Average Frictional Coefficient	0.567N/kg	0.704N/kg

CONCLUSION

Plastic wastes (pure water sachets and plastic bottles) which pose hazards to human beings and the environment can be converted into useful plastic based floor and wall tiles, using a simple recycling method which can be carried out by small cottage industries. It is recommended that recycling should be adopted as the main method of plastic waste management as it has various advantages such as reduction of the hazards caused by improper waste management, reduction in the use of fresh raw materials for products development, cheaper raw materials (wastes) for production. Based on the results obtained from chemical and mechanical tests, it can therefore be inferred that tiles produced from plastic waste and wood dust are cheap, durable and affordable when compared to the ceramic conventional tiles which are made with expensive raw materials. Hence, composite tiles made from plastic waste bottles/sachets and wood dust can be recommended as a reasonably good substitute for ceramic tiles.

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