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Quality Assessment and Recyclability of Plastic from Household Waste to Eco-Friendly Paver Block

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Abstract: *: This research qualitatively investigates the recyclability and durability of plastic waste once mixed with sand to yield plastic tile. Using plastic trash to create building materials like paver blocks is a part of the answer to environmental and ecological issues. In this study, three types of plastic waste polymers from household garbage were considered for the experiments. Plastic collecting, manual sorting, shredding, mould selection, creating sand to plastic ratio, and heat supply were different steps considered in the recycling process. For the manufacturing of plastic paver blocks, a cross-like mould and plastic to sand ratios of 1:1, 2:1, 1:2, and 1:1, respectively were considered. Under a melting temperature, the plastics and river sand were mixed in a container by using a stirring rod. The samples underwent a water absorption test, wherein, the results showed that trial 1, 2, 3, and 4, had water absorption test percentages of 3.8%, 5.1%, 3.7% and 19.3% respectively. Trials 1 and 3 had a low water absorption percentages, indicating a high-quality of plastic paver block that can be accepted. Trials 2 and 4 displayed unfavorable degrees of porosity and water absorption standards due to the high quantity of sand. Therefore, a mixture of equal quantity of sand and sectioned plastics as well as a mixture of half more plastic than the quantity of sand, can result into acceptable and durable tile provided they are thermoplastics. Conclusively, plastic paver blocks can be produced from wastes and have the ability to beautify a compound and can help contribute to an ecological friendly soil.*

Keywords: *Plastic waste, polymer, thermoplastics, plastic tile, sand.*

1. Introduction

Liberia like some African countries is experiencing an unprecedented disposal of plastics in the natural environment. This is mainly due to the status of the country (an underdeveloped country with developing and emerging economy). The average person in Liberia drinks at least a bag of mineral water (plastic bag water) or plastic bottle water a day. Once the water is consumed, its empty bag or bottle is eventually disposed in the environment adding to the estimated 10% household generated plastics wasted per day [1]. This has led to the contamination of the soil, a situation that is attracting the attention of researcher and the general public [2]. In recent years, too many countries around the world are finding possible solutions to mitigate the huge volume of plastic waste disposed in the environment [3]. While some countries have bans on waste being landfilled, there are still little percentage of plastic waste being landfilled [4].

Plastics are soft organic polymers made up of a wide range of synthetic or semi-synthetic organic substances of large molecular weight [5] and have the ability to last for centuries without decomposing [6]. Plastic is one of the important components of municipal solid waste (MSW) and it is one of the primary concerns for recycling [7]. On a daily basis, they serve the purpose of packaging electronic components, clothing and sports equipment, food products [8], additionally, they serve the purpose of food preservation [9]. Plastic waste is a global problem ranging from underdeveloped to developed countries. The used plastic has three fates in terms of pollution; it can remain in the soil causing soil pollution, erosion can take it into the river, causing water pollution or it can be burnt, causing air pollution [1]. The plastic waste once placed in a body of water can promote microbial colonization leading to outbreaks of disease in the water by pathogens [10].

Plastic waste can be grouped according to color and type. The grouping according to color is essential for the appearance of the plastic after recycling. The sorting according to types, aids in the quality of the product. Plastic waste comes in different colors and can be in the form of bottle or non-bottle. Few commonly known types of plastic waste are Polyvinylchloride (PVC), Polyethylene Terephthalate (PET), and Polyethylene (High-density or low-density) [11]. Others are polypropylene (PP), eg. bottle caps, and polystyrene (PS), eg. cups, egg cartons, etc. [12].

PET is seen in almost every dump site as it is often used in food packaging. It is strong with a very lightweight and mostly transparent. Examples include food bottles, beverage bottles, polyester ropes etc. [13].

Polyethylene is the most common plastic that can be grouped into high density, low density and linear low density. The high-density polyethylene has the ability to resist chemical and moisture making it suitable to be used as carton, containers, buckets, detergent bottle, etc. On the other hand, the low-density polyethylene is soft and can be used as liner on the cartons of beverages. Few examples are bread and sandwich bags, plastics and garbage bags, etc.

PVC is known to be hard and rigid which enables it to be resistant to chemical and weathering. It is used for construction applications, such as rain gutters, plumbing pipes, IV fluid bag etc. Generally, PVC and PET are the mostly used plastics on a global scale. Each types of plastic can be made of either or both thermoplastic and non-thermoplastic. Thermoplastics have the ability to melt when heated and can return to their plastic state in the absence of heat. Non-thermoplastics on the other hand do not return to their normal state once heat has been applied causing them to melt and or burn. Thermoplastics are associated with PE, PET and HDPE, while non-thermoplastics are linked to PVC, PS and PP [14].

COVID 19 led to a global health crisis that contributed to the pressure on waste management practice around the world. This led to inappropriate waste disposal practice, direct landfills and burning of waste [15]. Plastic wastes that are inappropriately disposed can either remain in the soil or be taken to water through erosion [3]. Since microorganisms cannot decompose plastics, they are known to be one of the pollutants [16]. Plastics in aquatic environment can contribute to the outbreak of diseases [17], thus, serving as threat to biodiversity [10]. It has also been discovered that marine litter has the ability to entangle one of every three marine life with about 90% of seabirds carrying plastics in their abdomen [18]. This is leading to the death of approximately 100,000 sea mammals and over one million sea birds each year [19].

The oceans can account for about eight million tons of plastics every year, which is predicted to outweigh the fish in the marine environment by 2050 if nothing is done to reduce this plastic pollution [20].

This study has the ability to create a plastic waste free environment, improve the economy by creating jobs for people who are responsible to have the plastic waste converted to tile. The financial benefit starts with the collectors of the plastics and ends at the point of sale of the tiles (the end product). With the removal of the plastic wastes from the soil, disease producing species that are linked to the remains of water in a plastic bag will not survive. Additionally, plastics in the soil can cause a plant not to extend its root deep in the soil for the absorption of nutrients, therefore, accounting for underproductions or death of the plant. One possible potential solution to this problem is to recycle the plastics in the production of yard tiles.

2. MATERIALS

During the production process, river sand, plastic waste, block mould, container, shovel, engine oil, firewood and stirring rod were used.

River sand was utilized in its natural form because it is well graded without rocks. In the research area, river sand was purchased from nearby sand miners, measured and used. The plastic wastes were sectioned and separated before used.

3. METHOD

Plastic waste collection and preparation procedure

Plastic wastes were collected from household waste on the campus of Cuttington University and its neighbouring communities. Examples of these wastes include mineral water bottles, water plastic (water bags or sachets), containers, and broken plastic chairs. A thorough cleaning was done on the plastic for the removal of any debris and other impurities that could affect how well the sand could mix with plastic during melting process.

The preparation of plastic waste for production

To make a plastic paver block, the following steps were used, Plastics Collection, Manual Sorting, Shredding and mixing with the aid of heat and stirring rod within a container. Basically, the types of plastics collected were in two thermoplastics and non-thermoplastics. They were separated and sectioned to avoid incomplete melting.

Manual Sorting

Theoretically, recycling is an option for all plastic types. Plastic bottles, chairs, and water bottles from Cuttington University campus and neighbouring areas were used as plastic waste for manufacturing paver blocks. Each type of plastic waste was segregated from the others, and unwanted materials as well as plastics that were not PE, PET, or HDPE were taken out of the waste. The thermoplastics were separated from non-thermoplastics for the determination of recycling ability.

Shredding

The plastic bottles and bags were cut into smaller pieces for drying using scissors. Many plastics wastes displayed in the environment are seen with water in them and must be removed or dried before melting.

Making a fire spot as electric power

Heat is required to melt the shreds of plastics. The power source was a stand of lit firewood. The plastics were melted using a container that was powered locally by electricity. It was built with firewood and stones (bricks). The firewood was positioned between the spaces of the stones that support the container.

Control Mix Design

To determine the proportion of plastic to sand needed to make one tile or block, the trial-and-error method was used. This accounts for estimating the ratio of sand to plastic and having it tested for use.

Trial mix design of plastic paver block (PPB)

PPB was produced through a trial-and-error method using a sand and plastic mixture to attain high strength levels. The acceptable ratios for mixing were 1:1, 2:1, 1:2 and 1:1, representing the quantity weights of sand and plastic in gram, respectively.

Manufacturing procedure or process

The waste plastic bottles, bags, and chairs that were gathered were used to make the components needed to make PPB. The steps taken in the production of PPB are listed below.

Melting Process

The sectioned-plastics were converted into liquid by heating the container to melting temperature and stirred with the aid of a stirring rod. The measured quantity of Sand was added and stirred for until a desire result was achieved.

Moulding and production of plastic paver blocks

The mixture was poured into the mould with a shovel and hand trowel, with the addition of used engine oil to prevent it from sticking to the already lubricated mould. Using a tamping rod or a short stick with a plate surface, the mixture was compacted into the mould until the desired amount of compaction was achieved. After a period of compacting, the mould was gently removed, leaving the compressed mixture (tile) on the ground.

Experimental Result

The water absorption test was used against each fully produced tile to determine its strength and quality.

The water absorption test determines the moisture content of the PPB. A sample of each trial was tested to determine a weight in a dry state, and later submerged in fresh water for 24 hours, after which the weight was tested. The amount of water the PPB absorbed accounts for the weight discrepancy. Mathematically, the higher the quality of PPB, the less water it absorbs. PPB of high quality doesn't absorb water more than 5% of its own weight. The test identifies the suitability of PPB in different ambient conditions. It indicates the degree of porosity, water-holding capacity, and quality of a material. The water absorption indicates the moisture content, which is equivalent to the difference between the wet and dry weights of PPB divided by the weight of the dry PPB and multiplied by 100 to express it as a percentage. The water absorption test was calculated using the formula below.

Water absorption (%) = [(W2 - W1) / W1] x 100

Where W1 = Weight of dry PPB (kg)

W2 = weight of wet PPB (kg)

4. RESULTS AND DISCUSSION

The mean values of six samples as trials were taken, of that number, three samples were PPB of suitable plastic and three were PPB of non-suitable plastic from household waste. This was done to determine the water absorption ability for each sample.

Table1. *Production Procedure Outcome of PPB*

Samples	Ratio: plastic to sand (quantity)	weight of sand in gram	weight of plastic in grams	Solidification	Degree of porosity	Weight of tile in kg	
						Dry weight	Wet weight
Thermoplastics -Trial 1	1:1	1500	1500	Solid	low	2.6	2.7
Thermoplastics -Trial 2	2:1	3000	1500	Very solid	medium	3.9	4.1
Thermoplastics -Trial 3	1:2	1500	3000	Semi-solid	low	2.7	2.8
Non-thermoplastics – trial 4	1:1	1500	1500	Semi-solid	High	2.6	3.1

The above table shows four different trials associated with plastic waste mixed with sand. The trials are grouped into thermoplastics (ability to melt) and non-thermoplastics (ability to burn). Using the same mould size for the four trials, the discrepancy is observed in weight after and before placing each in a sample of water. The measure of solidification and the degree of porosity were done to determine the ability of the tile to maintain its quality and the storage of water in it respectively. Accordingly, trials 1, 2, and 3 of the thermoplastics as seen in the below figures a, b, and c respectively resulted into yard tiles while trial 4 of non-thermoplastics resulted in a deformed and unwanted tile. Unlike trials 1 and 3, trials 2 and 4 displayed unfavourable degree of porosity. That is, they have the ability to store lots of water due to more sand to plastic ratios. Therefore, a mixture of equal quantity of sand and sectioned plastics as well as a mixture of half more plastics than the quantity of sand can result into acceptable and durable tile.

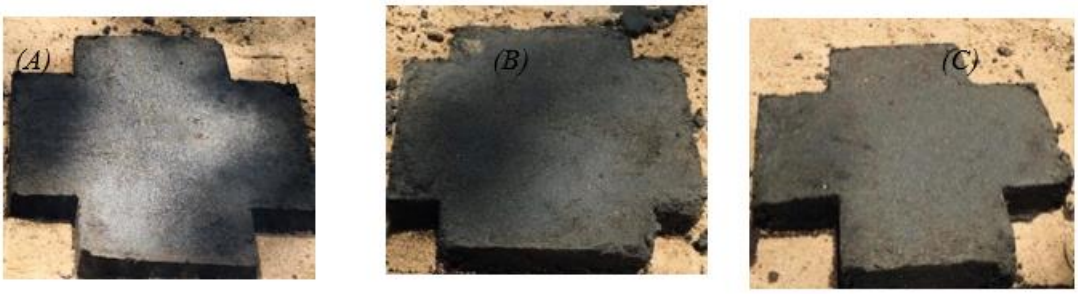

Figure1. *Images of production procedure outcome of PPB: (A) Trial 1, (B) Trial 2, (C) trial 3*

Table2. *Initial and Final Weights of PPB during the water absorption test*

Samples	Initial weight (dry weight in kg)	Final weight (wet weight in kg)	Difference	Percentage (%)
Trial 1	2.6	2.7	0.1	*3.8*
Trial 2	3.9	4.1	0.2	5.1
Trial 3	2.7	2.8	0.1	3.7
Trial 4	2.6	3.1	0.5	*19.3*

As shown in table 2, trials 1 to 4 have water absorption percentages of 3.8%, 5.1%, 3.7% and 19.3% respectively. A water absorption percentage of less than five is known to be favourable. In light of the above, trials 2 and 4 are known to be unfadable for us. These tiles are expected to be placed in an open field where rain falls directly on them. In the event they possess a very high porosity level, water will be kept in them leading to the growth of some plants species.

5. CONCLUSION

Plastics play an important role in modern society and are used daily in diverse applications due to their low cost, ease of manufacturing, and attractive qualities. Unfortunately, plastic waste brings serious environmental challenges to modern society due to their biodegradable nature. The percentage of recycled plastic can be increased by transforming waste plastic into mortar and concrete products suitable for housing and other construction works. In this study, plastics made of PET, PE, and HDPE were used as a replacement for cement mixed with river sand to produce PPB as yard tiles. Replacing cement with plastic waste will reduce environmental problems associated with the disposal of plastic waste as well as those associated with the cement industry. The result shows that a 1:1 and 2:1 ratios of plastic to sand respectively in thermoplastics can account for a favourable yard tile.

6. RECOMMENDATION

In the near future, the preparation method should be improved by introducing a closed ended container used for mixing and heating of plastic to avoid direct contact with the producers.

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