Innovative Farming and Building Materials from Recycled Plastics

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Abstract

Despite the ban on use of plastic paper bags, large amounts of plastic litter still exist in our environment. Plastic bottles form a greater percentage of the litter. The growth of the consumer market for cosmetics and soft drinks which are usually packaged in plastic containers continues to give rise to plastic pollution. To maintain the quality of the environment while achieving sustainable development plastic litter could be viewed as raw and innovative materials for making new items. Plastics can be recycled and made into furniture, ornamental products, and building blocks among others. This paper describes how recycling plastic waste into products of plastic sheets and blocks is conducted for multi-purpose use. The resultant sheets and blocks can be designed to have slots and extensions on the edges such that they allow interlocking the same way concrete interlock blocks work. The sheets and blocks can be used to make furniture, office partitions, and interior design. The sheets for furniture making can be craftily decorated with beads while they are still in molten state to produce ornamental furniture. This can be achieved through arranging beads in molds before introducing the molten polymers into them. The plastic blocks and sheets can also be used to make swimming pools and fish ponds. Heating temperature and oxidation should however be monitored to prevent degradation of the polymers. The resultant products are durable, attractive and affordable.

Key Words: Moulds, Waste management, Plastic, Recycling, Interlocking blocks, Degradation

Introduction

The significance of managing post-user plastics in order to achieve sustainable development cannot be overemphasized. The drastic amount of pollution from plastic waste can be seen in water bodies like oceans, lakes and rivers. Plastic wastes are nuisance in populated areas especially in cities. Plastic wastes in water bodies are very dangerous to marine life. Some sandy beaches along the coastline of Mombasa, Kenya have been abandoned after being flooded by plastic wastes (Muendo, 2000; Hoorweg & Muthiga, 2003; Salim et al., 2018). Plastic wastes form breeding grounds for mosquitoes especially in the rainy season when they are filled with water. Despite these, sites that could have been used for settlement or agriculture, are being used as dumping sites for litter.

The used plastic bottles and containers are a problem and will continue to be a menace if we do not have a different look at them. The increased consumption of bottled drinks and use of cosmetics is worsening the rate at which we are polluting our environment with plastics. In fact, a large component of municipal solid waste are plastics and the appropriate disposal methods are yet to be adequately controlled, especially in the counties of Mombasa, Nairobi and Kisumu (Fig. 1).

Figure 1. Mixed waste plastic requiring sorting before it can be recycled (Photo credit: Karama, 30th March 2019, Mombasa)

Recycling is one of the best methods of managing plastic pollution. However, the rate of plastic recycling in Kenya is still very low due to minimal innovations in this field. This paper proposes and describes new products from recycled plastic

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waste. It is important to distinguish various types plastic material when recycling them. Plastic materials can be classified as either thermoplastics or thermosets (Olmsted & Davis, 2001; Yhaya et al., 2018). Almost 80% of plastic produced today across the world are thermoplastics including polypropylene (PP), polyvinyl chloride (PVC), high-density and low-density polyethylene (PE), and polystyrene (PS). Thermosets account for only 20% and this type of plastic material cannot be recycled (Crawford & Throne, 2001; Crawford, 2012.)

The world population is growing fast and it is feared that the growing demand for resources will facilitate an increase in resource consumption and waste generation, contribute to deterioration of the natural environment and climate change, and impact future generations (Singh et al., 2017). To reduce poverty, hunger, and environmental problems and achieve sustainable development in diverse ways while dealing with this increase in world population, it is generally acknowledged that a multifaceted approach that integrates economic, social, and environmental aspects is needed.

In the quest for a solution, the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) was held in 2015. In this meeting, all participating countries adopted the epoch-making Paris Agreement that set long-term targets and obligated all member countries to update and enhance their reduction targets for greenhouse gas emissions every five years. In addition, the 2030 Agenda for Sustainable Development adopted by the UN General Assembly established Sustainable Development Goals (SDGs) as new and comprehensive global targets towards 2030 (World Health Statistics 2016; Hambrey, 2017).

Based on these movements, the G7 Toyama Environment Ministers' Meeting held in May 2016 adopted the Toyama Framework on Material Cycles and agreed upon a G7 Common Vision to enhance resource efficiency and promote the 3Rs (Reduce, Reuse, Recycle) and lay basic guidelines on future undertakings (Refurbishment & Reform, 2016). The 3Rs and resource efficiency were mainly aimed at controlling and reducing marine litter from plastic litter and land-based resources.

The process of recycling is changing and now new methods like mechanical recycling and feedstock recycling have been introduced. These two methods are being widely used for recycling used plastic material into fuels and plastic products (Ragaert et al., 2017; Gu et al., 2017; McCarthy et al., 2018). There is need to uphold the Third Fundamental Plan for Establishing a Sound Material-Cycle Society based on Japan's Basic Law for Establishing the Recycling-based Society (Moriguchi, 2006). The law states that measures with regard to waste shall be promoted as far as they are technologically and economically viable according to the priority stipulated in the Basic Law: 1) reduction of waste generation, 2) reuse, 3) recycled use, 4) heat recovery, and 5) appropriate disposal.

There are several state agencies in Kenya that have set up strategies to save the environment from pollution. These include: National Environment and Management Authority (NEMA), Kenya Marine and Fisheries Research Institute (KMFRI), and Kenya National Cleaner Production Centre (KNCPC). The KNCPC, for example, has provided some elaborate plastic waste management strategies for the City of Nairobi (Njoroge, 2017). These organizations have adopted various methods to realize improvements in waste management in the city. The County of Nairobi is currently in bad state as far as pollution of land is concerned. Components of these strategies include Rapid Results Initiative, Plastic Waste Recycling Demonstrations, Public Education and Awareness, Stakeholder Participation, Technology Support and Capacity Building, Good Environmental Governance and Networking, Actual Plastic Waste Recycling among others (Muniafu & Otiato, 2010).

This project was aimed at producing thick plastic sheets for multi-purpose use from recycled plastic material. The intended products of these plastic sheets would be used for room portioning, construction of plastic silos, construction of fish ponds, and used as plastic shelters. This would ultimately contribute to solid waste management, affordable and appealing building furniture products, as well as promoting fish and dairy farming.

Materials and Methods

Survey on Types of Plastics Available for Collection

Surveys for plastics were conducted in Nyali, Kisauni, Tudor, Changamwe, and other areas of Mombasa County. The surveys objectively focused

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on finding out areas within the county having more plastic wastes, ascertain the types of plastics available for collection, determine effective ways of collecting the plastic material and the economic viability for collection.

Plastic Collection Methods

The methods of collection were determined after completing our survey on the same and these included; collection from a transfer station, buying from plastic waste vendors operating from the municipal dumpsite, and regular collection from shops and hotels.

Identification of Different Types of Plastics

Thermoplastics were distinguished from thermosets by use of a red hot wire. The wire penetrates thermoplastics and does not penetrate thermoset plastics. The different types of thermoplastics can be determined by use of recycling triangles (Table 1). A recycling triangle is a triangular symbol with a series of numbers and letters that identify various types of thermoplastics.

Table 1. Recycling triangles for polymers (Yhaya et al., 2018)

Symbol	Acronym	Full name and uses
1	PET	Polyethylene terephthalate - Fizzy drink bottles and frozen ready meal packages.
2	HDPE	High-density polyethylene - Milk and washing-up liquid bottles
3	PVC	Polyvinyl chloride - Food trays, cling film, bottles for squash, mineral water and shampoo.
4	LDPE	Low density polyethylene - Carrier bags a bin liners.
5	PP	Polypropylene - Margarine tubs, microwa able meal trays.
6	PS	Polystyrene - Yoghurt pots, foam meat or trays, hamburger boxes and egg cartons, vending cups, plastic cutlery, protective packaging for electronic goods and toys.
7	Other	Any other plastics that do not fall into any the above categories. For example melam often used in plastic plates and cups.

Thermoplastics that lacked any recycling triangle were subjected to different treatments and identified accordingly using either of the following methods:

- Plastic material was reduced into smaller pieces. A few sample pieces were put on water with few drops of detergents added and checked whether the plastic pieces floated or sunk in the water.
- A piece of the plastic was held over a flame using a pair of tweezers. The manner in which the piece of plastic burnt and the flame color helped in its identification

Processing the Reclaimed Plastic Pieces

i) Initial Upgrading

Initial stages of the recycling included cleaning and sorting out the plastic material by polymer type and color.

ii) Size Reduction

The plastic materials were reduced into sizes of rice grains suitable for efficient melting. Larger plastic material such as buckets and water containers of more than 2 litres were reduced to medium sizes by cutting with appropriate tools. The smaller pieces were then shredded into further smaller pieces.

iii) Melting

Melting was done in two ways. Firstly, by melting the shredded pieces in a mold which had a heating coil wound around it. Secondly by melting the pieces in a heated barrel. The barrel had also a heating coil wound around it.

iv) Molding

Molding was done mainly through direct panning. Molten polymer from an oven was introduced into a molder. The mold was closed with a metal block and its weight pressed down the polymer as it solidified. The solidified polymer took the shape of the mold.

Results and Discussion

Huge heaps of plastic materials were found in most parts of Mombasa County. Hot spot areas included Maweni, Kibarani, Karama, and Mwembe Tayari. Most of the plastic materials were water bottles and buckets. Table 2 summarizes findings on the plastic tests.

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Table 2. Properties of thermoplastics

Polymer\Tests	Water	Burning	Smell after burning
Polyethylene (PE)	Floats	Blue flame with yellow tip, melts and drips	Candle wax smell
Polypropylene (PP)	Floats	Yellow flame with blue base	Candle wax smell but less strong to that of PE
Polystyrene (PS)	Sinks	Yellow, sooty flame – drips	Sweet smell
Polyvinyl chloride (PVC)	Sinks	Yellow, sooty smoke, Stops to burn if flame is removed	Like that of Hydrochloric acid

New Building Techniques Using Recycled Plastic

The molten polymers were molded into rectangular and square sheets (Figs. 2 & 3). Slots and extension were made on the edges of these sheets to allow sliding of one sheet into another.

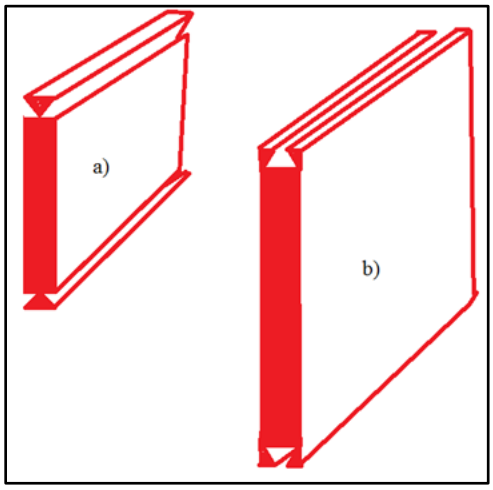

Figure 2. Designed plastic interlocking blocks molded from recycled plastic material

The plastic sheets can be used to make partitions or creating rooms especially for offices. They can be used together with plastic poles that take the same shape to create temporal shelters instead of tents. They can also be used to make extensions on buildings especially in recreational places like bars.

Plastic blocks take the same shape as the sheets. However, they are wider and are made up of two symmetrical sheets that can be joined by screws to form the block. The blocks should have hollow parts inside. The hollow part can allow insertion of insulation materials such as cotton. These blocks can be used to construct shelters that are able to insulate the occupants from adverse conditions such as very low temperatures.

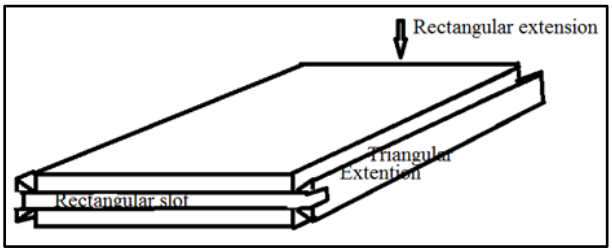

Figure 3. Three-dimension diagram of interlocking block

New Farming Techniques Using Recycled Plastic Material

The plastic materials can be used to make silos and fish cages. During the making of silos and fish cages, glue is applied in slots and on extensions to make the structures water proof. The plastic fish cages will replace the current concrete cages and silos (Fig. 4).

Figure 4. Concrete fish pond representing some of the current projects that can be done using interlocking blocks from plastic materials

Conclusion and Recommendations

Increased heaps of plastic waste in various parts of the country can be attributed to lack of cost-effective recycling methods. This project not only introduces a recycling technique that is affordable to most citizens but also brings new products into market. For these reasons the project is expected to promote the recycling process and ultimately reduce amount of plastic pollutants in various parts

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of the country. However, this project needs some improvements including automation of various stages of the recycling process such as polymer sorting, molding and temperature control.

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