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RECYCLED PLASTIC CONSTRUCTION BLOCKS AND BRICKS

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Abstract: Plastic waste was initially landfilled along with every other type of waste. This has proved not to be an acceptable long-term solution considering the time it takes plastics to decompose, which ranges from 100 to 600 years. The ideas about reusing plastics emerged as early as the 1970s. Any kind of production is inevitably accompanied by waste, which is generated both in the production facilities and as a result of worldwide product use. This points to a logical conclusion that, owing to the plastic production growth, the amount of waste generated over time increases on a daily basis. This paper discusses the possibility of using recycled plastics to produce construction blocks and bricks.
Keywords: plastic, recycling, building blocks, bricks

INTRODUCTION

Plastics are organic polymers composed of groups of monomers containing carbon and hydrogen. Natural polymers have been used since the dawn of humanity, whereas synthetic polymers are considerably more recent. Over the previous several decades, plastics gained popularity because of their ability to retain their mechanical properties after modeling, crushing, fabrication of threads, and post-use recycling. Plastic masses are processed using rolling into foils, injection molding, extrusion under pressure, etc. Owing to their mechanical and chemical properties, plastic masses have outperformed numerous other materials. Among other things, the use of plastics has been increasing owing to the low cost of the raw materials, small mass, and processing versatility.

Large amounts of plastic waste are deposited at landfills and often outside landfills. Waste disposal at landfills is unsuitable, because of its large volume and its weathering non-degradability.

Recycle plastic is used to obtain synthetic materials that are then used to produce clothing, foils, packaging (e.g., bottles, bins, barrels), and other products. It is only in recent years that recycled plastic has been used to produce construction blocks and bricks.

European plastics industry has opted to maximize the use of plastic waste as a resource and to minimize plastic waste disposal at sanitary landfills. This involves the utilization of plastics through mechanical or chemical recycling or as an energy-generating raw material, which is a path toward integrated waste management. Such a policy is in keeping with the EU Directive on packaging and packaging waste, which set a goal to utilize a minimum of 45% of packaging waste, 15% of which has to be recycled [2].

Of all packaging materials, plastic has enjoyed the highest growth rate over the previous decade. The first European strategy for plastics was adopted in Strasbourg in January 2018. Three years prior, the EU enacted the Circular Economy Action Plan, and the European strategy for plastics is the extension of this policy, which is supposed to regulate plastic production, use, and disposal flows and to incentivize a transition to circular economy.

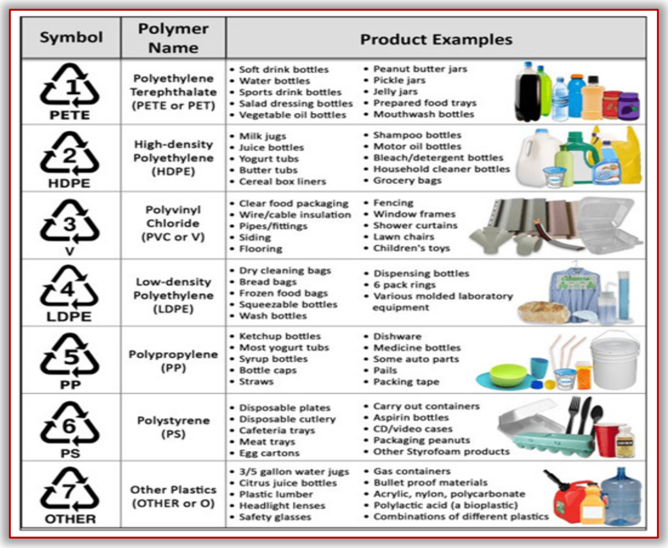
The goal is to ensure the reuse and recycling of all plastic packaging on the EU market by 2030. To ensure a higher demand for recycled plastics, the EU Commission also launched a campaign aimed at taking on the obligation of putting ten million tonnes of recycled plastics into new products across the EU by 2025.

The EU generates over 28 million tonnes of plastic waste annually. Less than 30% of that amount gets recycled, while the remainder is either incinerated or landfilled. Analyses have shown that such a high degree of landfill disposal and incineration incurs losses of 70 to 105 billion euros due to a short utilization cycle of the raw materials.

In everyday life, plastics are used for a wide variety of purposes, from clothing, footwear, and tableware to cosmetics and car parts. Plastic is a light material that is easy to produce and mold. It is highly resilient, which means that every piece of plastic ever produced still exists on earth in one form or another. These properties of plastic and irresponsible management of plastic flows have caused one of the crucial environmental issues affecting the planet – it is overrun by plastics.

In 2020, Serbia generated 356,021 tonnes of plastic waste, of which only 45,219 tonnes were recycled. [3,4].

In order to standardize and globalize recycling, special labels were globally adopted to inform customers about the material of which the product is made and to facilitate collection and subsequent sorting before recycling. The law mandates that every item has to contain a label informing the user about the material used to produce it. Figure 1 shows the universal symbols for labeling plastic materials (each type of plastic has only one symbol). Recycled plastics are classified according to their basic chemical composition.



Symbol	Polymer Name	Product Examples	
1 PETE	Polyethylene Terephthalate (PETE or PET)	• Soft drink bottles • Water bottles • Sports drink bottles • Salad dressing bottles • Vegetable oil bottles	• Peanut butter jars • Pickle jars • Jelly jars • Prepared food trays • Mouthwash bottles
2 HDPE	High-density Polyethylene (HDPE)	• Milk jugs • Juice bottles • Yogurt tubs • Butter tubs • Cereal box liners	• Shampoo bottles • Motor oil bottles • Bleach/detergent bottles • Household cleaner bottles • Grocery bags
3 V	Polyvinyl Chloride (PVC or V)	• Clear food packaging • Wire/cable insulation • Pipes/fittings • Siding • Flooring	• Fencing • Window frames • Shower curtains • Lawn chairs • Children's toys
4 LDPE	Low-density Polyethylene (LDPE)	• Dry cleaning bags • Bread bags • Frozen food bags • Squeezable bottles • Wash bottles	• Dispensing bottles • 6 pack rings • Various molded laboratory equipment
5 PP	Polypropylene (PP)	• Ketchup bottles • Most yogurt tubs • Syrup bottles • Bottle caps • Straws	• Dishware • Medicine bottles • Some auto parts • Pails • Packing tape
6 PS	Polystyrene (PS)	• Disposable plates • Disposable cutlery • Cafeteria trays • Meat trays • Egg cartons	• Carry out containers • Aspirin bottles • CD/video cases • Packaging peanuts • Other Styrofoam products
7 OTHER	Other Plastics (OTHER or O)	• 3/5 gallon water jugs • Citrus juice bottles • Plastic lumber • Headlight lenses • Safety glasses	• Gas containers • Bullet proof materials • Acrylic, nylon, polycarbonate • Polylactic acid (a bioplastic) • Combinations of different plastics

Figure 1. Plastic labeling symbols

Regarding the recycling process itself, it should be emphasized that there are four types of recycling: primary, secondary, tertiary, and quaternary. The classification was established based on product lifecycle, which then dictates its later use after recycling.

- Primary recycling: Re-extrusion, or return of the plastics with the same properties into the production process. If the molding of plastic products generates waste (e.g., a material left over after trimming the product edges, a material that goes through a machine first during processing and is then discarded, a product that does not meet the shape requirements, etc.) that remains within the production facility, it is considered uncontaminated and may be returned to the polymer processing procedure.
- Secondary recycling: Mechanical recycling, developed to recycle different plastics using physical procedures. When a material leaves the production facility and is collected after its shelf life, cleaned of all traces of other materials, washed, and dried, it can be reshaped through processing, pure or combined with a pure polymer and other materials. Mechanical recycling is the only one of the four recycling types that maximizes the utilization of plastic waste while minimizing the negative environmental impact. When using mechanical recycling, it is important to select a suitable method of sorting and different processing stages. Despite the rapid technological progress, manual sorting of plastics is still the most common method, as it is a simple process requiring little technological support. It is a labor-intensive, cost ineffective, and inefficient method for sorting any material, especially plastic. Consequently, a labeling system was introduced with codes for the six most used types of plastic.
- Tertiary recycling: Chemical recycling is used to produce raw materials for the chemical industry. It is a process decomposing plastic materials into polymers with lower molecular mass (usually liquids or gases), which are then used as raw materials for new petrochemical products or plastics [1]. The term *chemical* is used because the process changes the chemical structure of the polymers.
- Quaternary recycling: Its purpose is energy generation, or complete or partial oxidation of plastic waste to produce heat and/or gaseous fuels and oils and/or disposable materials (e.g., ash). Parts of the waste, most often specific types of polymers that cannot be processed using any of the previous three procedures, may be used for energy generation or as fuels, both on their own and combined with other wastes and fuel to generate heat due to the breaking of chemical bonds.

RECYCLED PLASTIC CONSTRUCTION BLOCKS

ByFusion Global Inc., a US company, plans to recycle 100 million tons of plastics and convert them into construction blocks by 2030. ByFusion Global created a new alternative construction material. ByFusion's Blocker system converts 100% of plastic waste into ByBlock® – an advanced and affordable construction material. ByBlock® is a multi-colored construction block made of recycled plastic. Its dimensions are 40x20x20cm and it weighs 10kg. It is the first construction material made entirely out of recycled (and often un-recyclable) plastic waste. The blocks are designed to be placed without any glue or adhesive, the same as regular concrete blocks. However, as opposed to concrete blocks, ByBlocks® do not crack or crumble.

Figure 2. Recycled plastic blocks – ByBlock

The manufacturer claims that the production of these blocks generates zero waste. One ton of plastic yields one ton of ByBlocks®. These multi-colored construction blocks are visually appealing and functional. They can be used for the construction of retaining walls, sound walls, sheds, terracing, and even furniture. They can replace cement blocks in building foundations or indoor walls and are no different than concrete blocks.

The manufacturer also stresses that the production process has zero carbon emissions and does not require any additional chemicals. The plastic is not melted during recycling and standard construction materials such as plaster walls and tiles may be added later. Greenhouse gas emissions of ByBlock® production are 41% lower than emissions during concrete block production [5].

CONSTRUCTION BLOCKS MADE OF RECYCLED PLASTIC AND SILICATE WASTE

Indian company Rhino Machines invented a new design technology for plastic construction blocks. The blocks are called silica plastic blocks (SPBs) and are strong enough to be used for building a house. *Rhino Machines* conducted experiments to determine the sustainability of these blocks made from plastic waste and silicate foundry dust. The experiments were conducted by the company's R&D division to prove that SPBs can be used in construction instead of traditional blocks. The general goal was to attempt to find a permanent solution for the growing issue of plastic waste in India.

According to the Indian Central Pollution Control Board data from 2012, India produced over 23,500 tonnes of plastics daily, of which 10,000 tonnes were deposited with other waste without being sorted. This waste is non-biodegradable and reaches the natural environment, polluting rivers, agricultural land, and the entire environment.

Figure 3. Figure caption

Initially, the aim of creating SPBs was to achieve zero discharge from the foundry reclamation process. In the early stages of the experiments, tests were conducted using foundry dust mixed with cement to produce bricks. The experiment yielded the following results: 7-10% of recycled waste went into concrete bricks and 15% into clay bricks. The experiments indicated that other resources, such as cement, earth, and water, were also required, which was not justified by the recycled waste. Further research resulted in the mixing of foundry dust with plastic waste, which was used as a bonding agent, thus eliminating the need for water and cement during mixing. SPBs require a mixture of approximately 80% foundry dust and 20% plastic, which means that neither water nor cement are necessary. Such blocks are less dependent on natural resources, while also reducing inorganic waste. According to *Technology Times*, SPBs are 2.5 times stronger than standard red clay bricks and their production costs are lower owing to the use of waste [8].

Even though some countries banned the use of single-use plastic products, the problem with plastic waste gives serious cause for concern. Therefore, technologies such as SPBs could significantly help reduce the amount of plastic waste. In addition to contributing to the solution of the plastic waste problem, such technologies should also help alleviate another global problem, which is the growing demand for residential space in urban environments. According to UN data, 55% of the world population reside in urban environments, where the problem of plastic waste is logically more pressing. It is estimated that about 68% of the world population will live in urban areas by 2050.

RECYCLED PLASTIC BRICKS

The House in Colombia shown in Figure 6 was built from recycled plastic by Fernando Llanos. Together with the architect Óscar Méndez, he founded the company Conceptos Plásticos, which patented the innovative system of construction using recycled plastic bricks, which allowed the cheap and fast construction of houses at difficult-to-reach locations. The construction of a plastic house with the total surface area of approximately 40 m^2 cost 6,000 euros and took only five days. The plastic bricks were joined together similar to LEGO® blocks.

Plastic bricks have good insulation properties, they are not flammable, and they comply with the local seismic building codes. Since 2011, the company has employed 15 persons to build plastic brick houses in areas affected by natural disasters [7].

Figure 4. A house made of recycled plastic bricks

Located in Alta Gracia, province of Córdoba, Argentina, the non-profit organization Ecoinclusión works to reduce plastic waste, specifically PET bottle waste, by producing recycled plastic bricks. These bricks are also intended for housing construction in vulnerable areas. The bricks received the technical certification by the *UN – Habitat Secretariat*, after being developed by *Ceve-Conicet*. The production of one plastic brick requires twenty recycled bottles. The brick's properties are similar to a standard clay brick's but with better thermal insulation characteristics [9].

Figure 5. A recycled plastic brick

The Kenyan startup Gjenge Makers, located in Nairobi, founded by 29-year-old Nzambi Matee, developed a cheap recycled plastic paving brick, which is harder than concrete bricks. Nzambi Matee was declared the Young Champion of the Earth 2020 for Africa by the UN Environment Programme (UNEP). The plastic waste paving bricks are now used to pave households, schools, and streets.

She conceived and developed a prototype of a machine that converts plastic materials into pavers for paths and sidewalks. The machine's output capacity is 1,500 plastic pavers a day. The production is cost-effective because waste is used and their superior hardness makes them ideal for the paving of areas that require harder materials.

Figure 6. Recycled plastic pavers in different colors

The company's innovations in the civil engineering sector offer both economic and environmental benefits, because they involve a transition from linear to circular economy, in which products remain in the system as long as possible. Thus far, more than 20 tonnes of plastic waste have been recycled to produce paving bricks and tiles in a variety of colors (red, blue, brown, and green). Testing showed that they are two times stronger than regular concrete bricks [10].

CONCLUSION

The entire world is facing the problem of plastic waste today. Modern life is almost unimaginable without polymers, as everyday items, clothing and footwear, vehicles, construction materials and products, and information and communication devices are made of different types of polymers. Waste generation accompanies any kind of production, whether in production facilities themselves or as a result of product use throughout the world. Consequently, the increased production of plastics generates increasing amounts of plastic waste on a daily basis. Initially, plastic waste was landfilled with other waste, but it soon became clear that this could not be a long-term solution, because of the long period of plastic degradation.

Many plastic materials can be reused to create new items that are used in every sphere of life. The obtained plastic regranulate is used directly in the production of plastic items. This paper discussed how the plastic regranulate may be used to produce recycled plastic construction blocks and bricks. These new construction materials are then used for the construction of residences and for outdoor paving.

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