The International Maritime Transport and Logistics (MARLOG 13) - ISSN 2974-3141
http://dx.doi.org/10.21622/MARLOG.2024.13.1.63
Towards Smart Green Blue Infrastructure

Improving the River Nile Sustainability through Recycling Retrieved Plastic Waste

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ABSTRACT

This work represents collaboration between the research team and the VeryNile organization aiming to improve the sustainability of the Nile River by cleaning the Nile from plastic waste recycling this waste into a value-added product. VeryNile was launched in 2020 to empower the local fishermen to clean the Nile daily. Every day, this green army removes an average of 100kg of plastic waste from the Nile, which is almost 40 tons per year. Mixed with about 60 tons of agricultural waste, we could produce 100 tons of wood plastic composite (WPC) every year. In this research, wood plastic composite was produced from recycled high-density polyethylene (HDPE) and different types of agriculture wastes. Agriculture wastes were dried in the sun for about one month. Then wood powder was produced from these wastes using three steps: cutting, crushing, and grinding. HDPE waste was cut using plastic crushing machine to produce plastic flakes. Then, plastic pellets were produced from these flakes using plastic pelletizer machine. Finally, wood flour and plastic pellets were mixed, compounded and formed into the final shape using conical double screw extruder. Tensile test, bending test, and water absorption test were done on the produced samples. results show that the mechanical and physical properties of the produced WPC are suitable for many applications: decking, fencing, seat, garden toys, and kitchen cabinet. WPC produced from cotton stem was found to have maximum tensile strength while WPC produced from chili peppers stems wood` was found to have maximum bending strength. WPC produced from orange tree wood gave minimum water absorption. So, it's the most suitable type for outdoor applications.

Keywords: Nile River, Sustainability, water resources pollution.

INTRODUCTION

Plastic have spread use due to its desirable properties like light weight, durability, flexibility, cheapness, and easiness of production. Increasing demand for plastic makes plastic wastes really a problem. It results in catastrophic effects on the environment [1]. Burning plastic wastes results in highly toxic dioxin [2]. Egypt produces 5.4 million tons of plastic every year, making it the biggest plastic polluter in the Arab world [3]. A recent report by the WWF (World Wide Fund for Nature) revealed that Egypt pours 250,000 tons of plastic waste in Mediterranean each year [3]. According to the World Economic Forum, River Nile is one of ten rivers that contribute 90% of garbage in the world oceans. This garbage contains huge amount of plastic waste. Plastic waste causes untold harm to marine life. It is estimated that marine

plastics contribute to the death of more than 100,000 marine mammals every year. In addition, plastic debris causes the deaths of more than a million seabirds each year [4].

Agriculture wastes also have been a major source of pollution. In Egypt, the amount of agriculture wastes ranges from 30-35 million tons a year. Only 7 million tons is used as animal feed and 4 million tons is used as organic manure. The problem of agriculture wastes arises after harvest of summer crops because farmers are in a rush to cultivate their land. Therefore, they get rid of the waste usually by burning causing emission of poisons gases to the air and reducing the microbial activities in the soil [5].

Wood plastic composite (WPC) is a composite material made of wood fiber/wood flour, thermoplastic as polymer bonding, and small percentage of additives which is added to enhance physical and mechanical properties of the produced composite in addition to facilitate the production process. WPC is widely used in decking, fencing, garden furniture, cladding, and kitchen cabinets. Since WPC usually has lower mechanical properties than solid wood, it is not used in applications where strength and stiffness are critical. WPC considers one of the solutions to environmental problems caused by plastic and agriculture waste. It is a powerful tool to recycle plastic and agriculture wastes. In addition, WPC has an advantage over formaldehyde-based particle boards because it does not contain formaldehyde which causes many diseases [6].

LITRETURE REVIEW

The first wood plastic composite (WPC) was produced in 1983 by American Woodstock, an automotive interior company based in Sheboyen, Wisconsin. Polypropylene and wood flour with equal percentage were mixed and extruded to produce a flat sheet which was then formed to various shape for automotive interior purpose [7].

WPCs can be produced using different species such as radiate pine [8], coconut coir, bagasse, pineapple leaves [9], chili stems [10], cornstalk [11], albezia richardiana kind, prain [12], cunninghamialanceeolate, pinus taiwanensis, tremaorientalis, and phyllostachysmakinoi [13].

Thermoplastic polymers melt and flow at high temperatures and harden when cooled. Thermoplastics are used as matrix materials for wood particles. The processing temperature of the thermoplastic used in WPCs must be less than the thermal degradation temperature of wood (~200°C). Low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polystyrene (PS), and Polyvinyl chloride (PVC) are suitable for use in WPCs in virgin and recycled forms [14, 15]. WPCs made with polypropylene are widely used for exterior building components such as fencing and decking, while polypropylene composites are mainly used in transportation applications [16].

The key to making any WPC is through efficient dispersion of wood fiber into the thermoplastic matrix (compounding). Generally, this can be accomplished using twin-screw extruders or other melt-blending processes. Once the materials are sufficiently mixed, the composite can then be formed into the final shape using forming processes such as extrusion or injection molding [17].

WPC has many advantages over both of wood and plastic. Compared to wood, WPC is mold resistance and recyclable. It does not generate cracks easily. The plastic constituent of WPC enables producing complex shapes using various forming technology. In addition, different additives can be added to WPC to enhance physical and mechanical properties. Compared to plastic, WPC can be sawed, bonded, and fixed with nails and screws. The cost of product is low compared with the same plastic product and the surface hardness of WPCs is higher than plastic [18].

EXPERIMENTAL

VeryNile and its approach to clean River Nile

VeryNile is an Egyptian organization aims at build more eco-friendly communities through solving the problem of marine litter using socially empowering and innovative approaches. VeryNile empowers local fishermen to clean the Nile daily. In exchange for cleaning the Nile, fishermen get financial incentive, social insurance, and social services (access to educational and healthcare services). The following sections show how to produce wood plastic composite from both of plastic waste collected by fishermen and agriculture waste collected from farmers to add value to these wastes.

Preparation of wood powder from agriculture wastes

The preparation of wood powder from agriculture wastes included three steps as shown in Figure 1: wood cutting, wood crushing, and wood grinding. Moisture in wood particles can create voids, which adversely affect the mechanical properties of the final product. So, wood flour should be dried in an oven at a temperature of 80°C for 24 hours. This was done to control the moisture content between 2 to 8 percent.

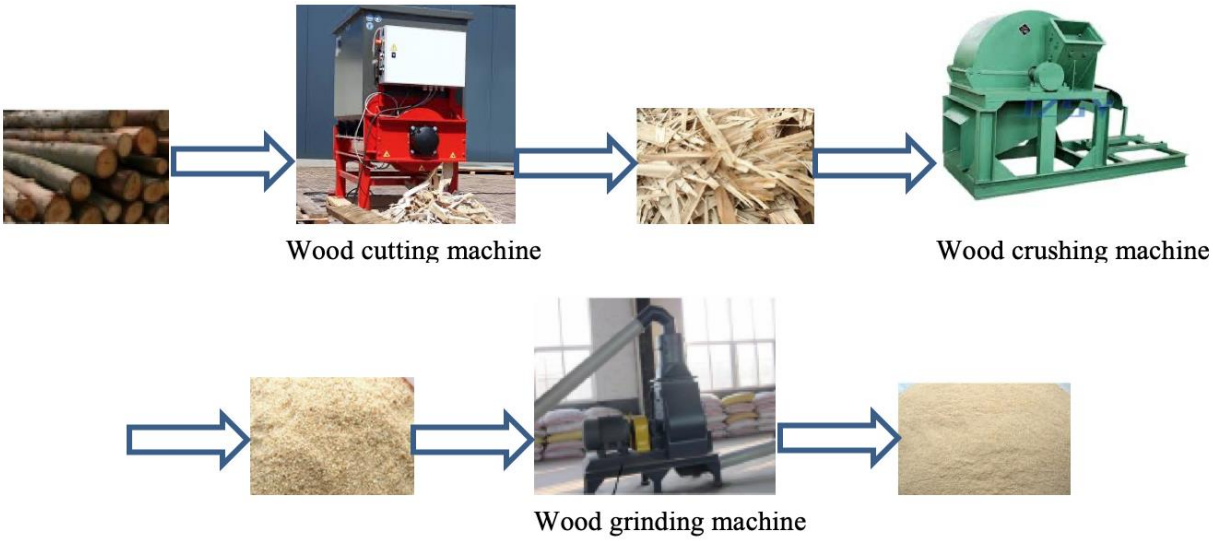

Figure 1: Preparation of wood powder [19].

Preparations of plastic pellets from River Nile plastic wastes

Preparation of plastic pellets from River Nile plastic wastes includes five steps: collecting, sorting according to plastic type, washing, crushing, and pelletizing. Crushing and pelletizing processes are shown in Figure 2.

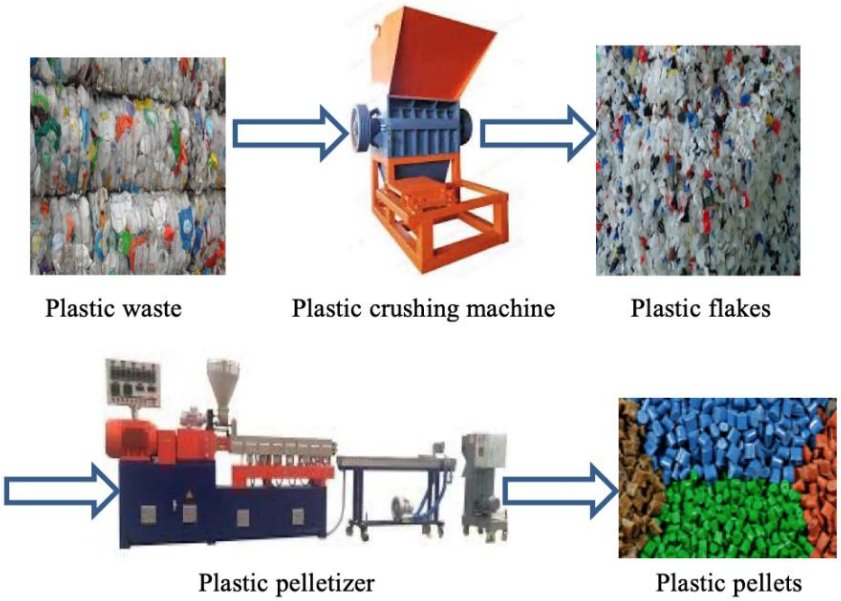

Figure 2: Crushing and pelletizing process.

Production of WPC from wood flour and plastic pellets

Wood flour and plastic pellets were mixed using a mixing machine. The mixture was put in the feeder of conical double screw extruder equipped with mold and online cutting device as shown in Figure 3. Many shapes can be produced depending on the mold shape.

Figure 3: Conical double screw extruder.

Testing

It was important to measure mechanical and physical properties of the produced WPC to determine the suitable applications in which it can be used. Tensile test, bending test, and water absorption test were

done on the produced WPC according to ASTM D7031 standard (Standard Guide for Evaluating Mechanical and Physical Properties of Wood-Plastic Composite Products). Tensile test specimens were cut using die cutter and die cutter press while bending and water absorption test specimens were cut using electric saw. Tensile and bending test setting are shown in Figure 4 and 5 respectively. Water absorption test specimens were dried in an oven at 50oC for 24 hours and then placed in desiccator to cool. Immediately after cooling the specimens were weighed. The specimens were then emerged in distilled water at 23oC for 24 hours. The specimens were removed, patted dry by a lint free cloth, and weighed. Water absorption was calculated according to the following equation.

Water absorption = (w24-w0)/w0 ..... (1)

Where:

W24 is the sample weight after 24 hours merging in distilled water at 23oC, and

W0 is the initial weight.

Figure 4: Tensile test setting.

Figure 5: Bending test setting.

RESULTS AND DISCUSSION

In this research, WPC was produced using different types of agriculture wastes. Samples were produced in the Plastic Technology Center Laboratory, Alexandria, Egypt. Table 1 and Figure 6 below show the tensile strength, bending strength, and water absorption for WPC produced from equal percentages of recycled HDPE pellets and different types of agriculture wastes.

Table 1. Tensile strength, bending strength, and water absorption for WPC produced from recycled HDPE and different types of agriculture wastes

Wood type	Tensile strength (MPa)	Bending strength (MPa)	Water absorption %
Orange tree wood	19.6	14.6	6
Cotton stem wood	21.5	11.1	7
Casuarina tree wood	12.8	12.9	7
Camphor tree wood	12.5	18.4	9
Chili peppers stem wood	17.9	25.1	7

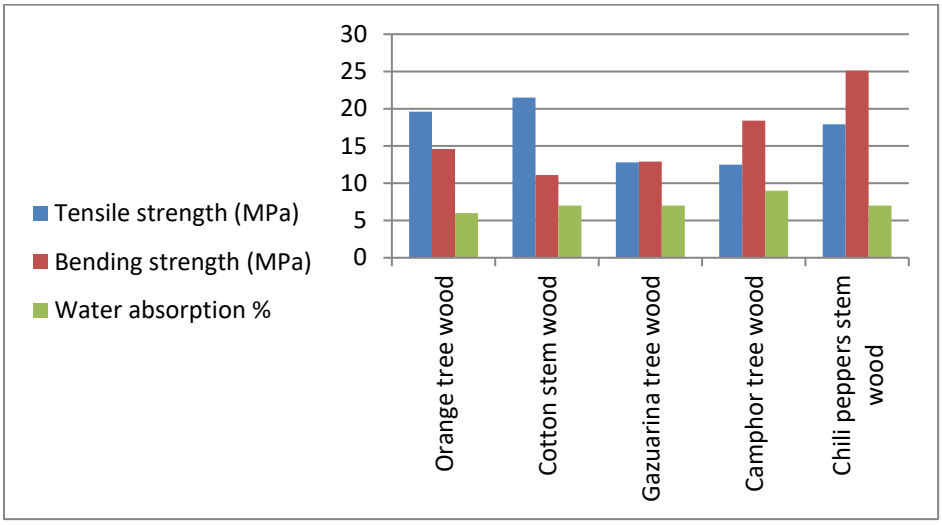

Figure 6: Tensile strength, bending strength, and water absorption for WPC produced from recycled HDPE and different types of agriculture wastes.

CONCLUSIONS

The previous results show that the mechanical and physical properties of the produced WPC are suitable for many applications: decking, fencing, seat, garden toys, and kitchen cabinet. WPC produced from cotton stem was found to have maximum tensile strength while WPC produced from chili peppers stems wood was found to have maximum bending strength. WPC produced from orange tree wood gave minimum water absorption. So, it's the most suitable type for outdoor applications. Finally, we can say that WPC is a successful tool for recycling both of agriculture and plastic wastes and adding values to them.

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