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Physico-Mechanical Properties of Waste Low-Density Polyethylene Reinforced with Jute-fibre Mat Composite for Automobile Application

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Abstract

The objective of the study was to determine the physico – mechanical properties of jute – fibre mat reinforced waste low density polyethylene. The composites were fabricated using waste low density polyethylene collected from dump sites and plain-woven jute - fibre mat. The formation of composites was carried out using compression molding technique and characterised to determine the mechanical and physical properties of the composites prepared. Findings showed that the composite had an optimum tensile strength of 23.36 MPa (26 % fibre loading), tensile modulus of 1.80 GPa (26% fibre loading), Flexural strength of 22.12 MPa (26 % filler loading), Flexural modulus of 0.4 GPa (26 % fibre loading), Impact strength of 37.96 kJ/m^2 (26 % fibre loading), Density of 0.998 g/cm^3 (34 % fibre loading) and water absorption of 4.2 % (34 % fibre loading).

Keywords: Physico-mechanical properties, Waste low-density polyethylene, Composites Jute-fibre mat, Compression molding

1.0 Introduction

Plastics constitute one of the major sources of environmental pollution be it aquatic or terrestrial. There is need for the problem posed to be addressed in a way that does not compromise our environment and also converts these pollutants into useful products that can be applied in our homes, automobile industry or construction depending on the characteristics defined by investigations carried out.

The disposal of these plastic bags in Gashua town, Bade Local Government Area of Yobe State constitutes environmental pollution leading to poor drainage of water during the rainy season making these drainages serve as breeding ground for mosquitoes, thereby causing recurring malaria fever amongst the human population. Tsala – Mbala *et al.* [1] worked on the technical and economic viability of distributed recycling of

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low-density polyethylene water sachets into waste composite pavement blocks.

Yang *et al*., [2] discussed the Chinese solution to global problem: the situation and countermeasures of marine plastic waste and microplastics pollution governance system in China. Rajmohan *et al*. [3] discussed Plastic pollutants: effective waste management for pollution control and abatement. In their work they looked at plastics and their associated health and environmental risk; impact of plastics in marine and fresh water; health impact of plastics on humans and discussed the plastic waste treatment in India; physical methods, thermal treatment technique and biological method.

Ravichandran *et al*. [4] investigated the Dynamic Mechanical Analysis of Low-Density Polyethylene Hybrid Polymer Composite. Dugvekar and Dixit [5] studied the Mechanical Properties of Jute and Rice Stalk Dust reinforced High Density Polyethylene. Ndukwe *et al*. [6] in the work titled prediction of compressive strength of bamboo reinforced low density polyethylene waste composites found out that the compressive strength and hardness of the matrix increased with increase in reinforcement, with 20% having the greatest hardness value and compressive strength. Dugvekar and Dixit [5] concluded in their work on rice stalk dust and jute fibre reinforced high density polyethylene that materials made could replace wooden and other conventional materials based on the characteristics displayed by the composites.

Sultana *et al*. [7] concluded based on their findings that saw dust low density polyethylene has higher mechanical properties than pure low-density polyethylene. They went further to state that oxidised saw dust exhibited better fibre – matrix adhesion due to absence of intermolecular hydrogen bonds.

Bhuiyan *et al*. [8] determined the properties of heat insulating jute reinforced recycled polyethylene and polypropylene bio – composites for energy conservation in buildings. Their findings showed that the developed composites exhibited adequate resistance against tensile and flexural load, a satisfactory resistance against radiating and conductive heat and there was low water absorption which suggest durability of the composites in buildings in a humid atmosphere.

The findings of Bhuiyan *et al*. [8] showed a higher water absorption compared to what was determined in the present work, this could be attributed to poor interfacial bond between the polymer matrix and jute fibre.

There is limited information in literature regarding jute fibre reinforced low density polyethylene waste (water sachets). The objective of this work was to determine the Mechanical and Physical Characteristics of the fabricated composites.

The work seeks to establish the best fibre loading for excellent mechanical properties (Tensile, Flexural and Impact strength respectively) of jute fibre reinforced low density polyethylene waste.

The work also seeks to determine the physical characteristics of the composite after fabrication and how the fibre loading affects it. Natural fibre reinforced composites produce composites that are also environmentally friendly in addition to the light weight they provide [14].

2.0 Materials and Methods

2.1 Materials

Waste Low density polyethylene from table water factory (SALGASH) along Yusufari Road, Gashua was sourced from dump sites, Jute-fibre mat (250 g/m^2) was sourced from Metro Home Centre - Menlyn, Pretoria, South Africa.

2.2 Method of Preparation of Composites

The waste low density polyethylene (LDPE) were washed and dried before being cut into smaller pieces (using a pair of scissors) for easy compression using Compression molding machine from Wenzhou Zhiguang Shoe Smacking Machines Co Ltd , after which they were compressed into thin films of 1mm at 130 ^oC under a pressure of 4 MPa for 2 min, this was then sandwich with the jute mat to form the composites 17 % fibre loading (two sheets), 26 % fibre loading (4sheets) and 34 % fibre loading (6sheets) respectively at 130 ^oC under 4 MPa for 3 min and then cooled under same pressure for 5 min. (The method used here was not from any literature but my knowledge about processing temperature for thermoplastics being above the melting point to enable proper impregnation of the reinforcement)

2.3 Characterisation

Characterisation of the composite materials were done according to ASTM Standards; ASTM D638 – 14 [9] for tensile strength using tensile strength tester TM 2101T, ASTM D790 – 03 [10] for Flexural strength using Universal Materials testing machine 100kN, ISO – 01 for Impact strength using Ceast Resil Impactor, ASTM D570 – 98[11] for Water absorption and ASTM D792 – 08 [12] for Density respectively.



17% Jute fibre loading (2layers) | 26% Jute fibre loading (4layers) | 34% Jute fibre loading (6layers)

Figure 2.1: Fabricated Composite plates

Figure 2 shows the fabricated composite plates, the colour is as a result of the colour of the writings on the sachets. The samples for characterisation were cut from the composite plates.

3.0 Results and Discussion

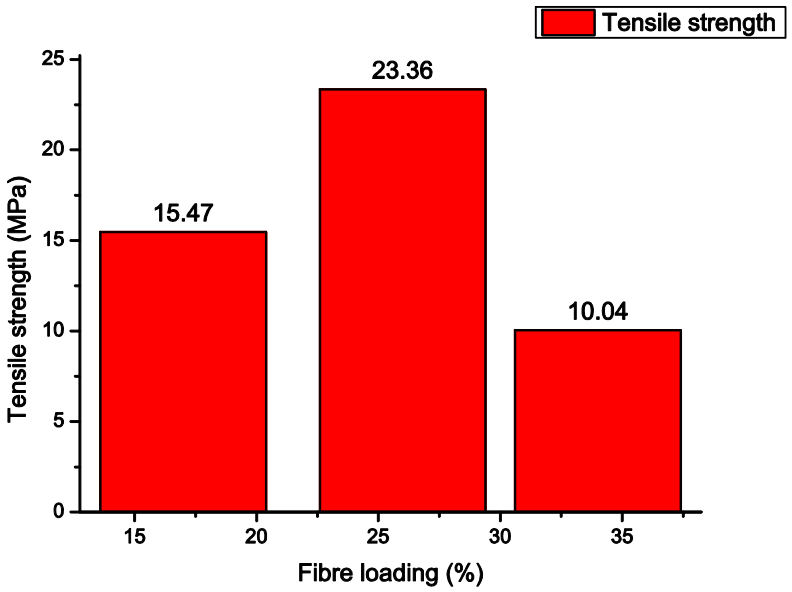


Figure 3.1: Effect of Jute-fibre loading on tensile strength of Waste low-density Polyethylene composite.

3.1 Tensile properties

The tensile strength of the jute fibre reinforced Waste Low Density Polyethylene (JF/PE) is as shown in Figure 3.1. The results shows that the prominent tensile strength of the composite is when the fibre loading is 26 % (23.36 MPa), anything greater than 26 % lowers the tensile strength. Inegbedion *et al*. [13] investigation had highest tensile strength at filler loading of 40 %. Danladi *et al*. [14] reported a tensile strength of 56.4 MPa at fibre loading of 27 %. Dugvekar and Dixit [5] reported that reinforcing High Density Polyethylene with 15 % jute and 15 % rice stalk dust gave 25.68 MPa; this was close to the value obtained from the present work.

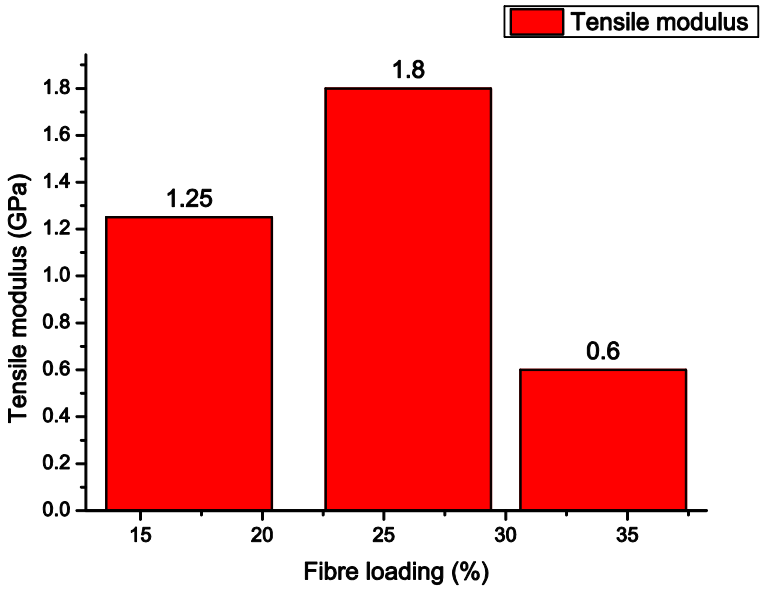


Figure 3.2: Effect of Jute-fibre loading on tensile modulus of Waste low-density Polyethylene composite

The tensile modulus of the jute mat reinforced Waste Low Density Polyethylene Composite is presented in Figure 3.2. The result also revealed that the prominent fibre tensile modulus was when the fibre loading was 26 % (1.8 GPa) and drops when the fibre loading exceeds 26 %. Inegbedion *et al*. [13] reported tensile modulus at filler loading of 50 % (387.99 MPa).

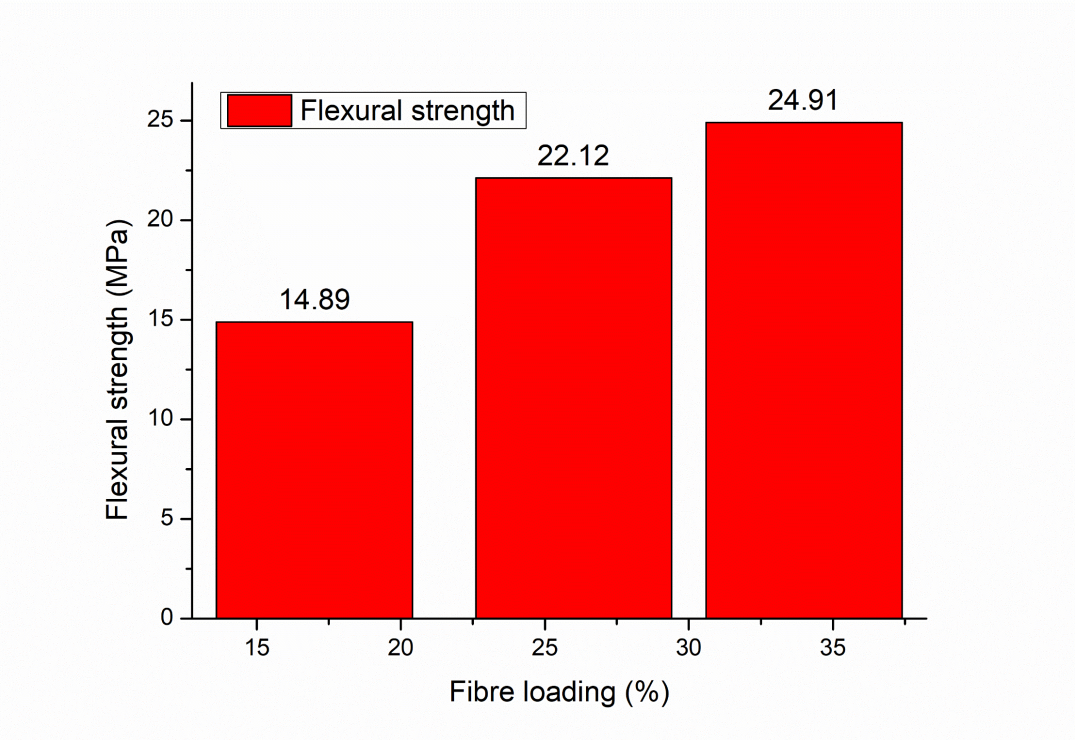


Figure 3.3: Effect of Jute-fibre loading on flexural strength of Waste low-density Polyethylene composite

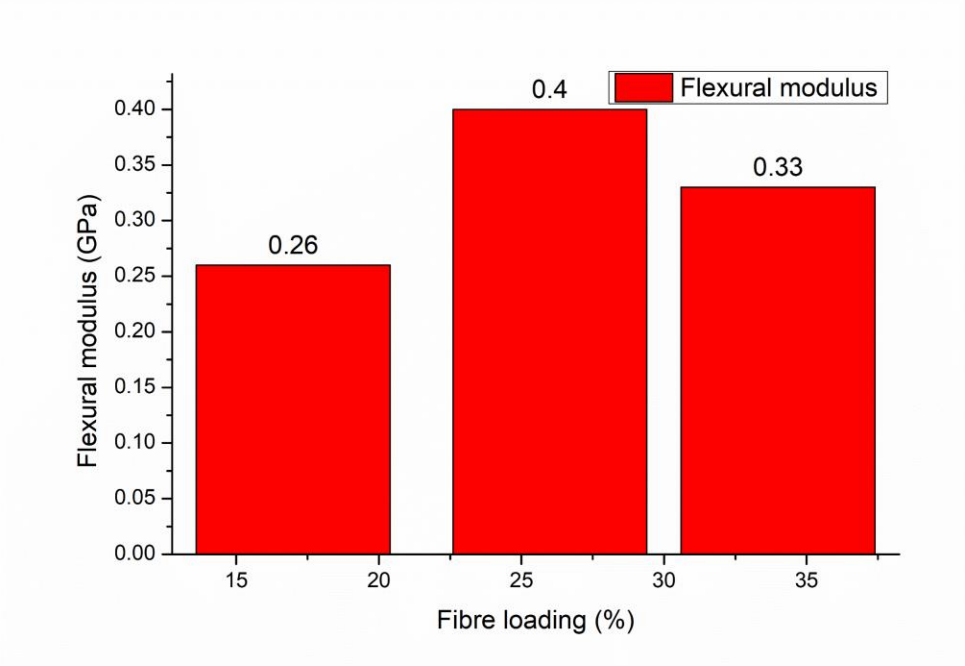


Figure 3.4: Effect of Jute-fibre loading on flexural modulus of Waste low-density Polyethylene composite

3.2 Flexural Properties

Flexural strength of the jute fibre reinforced waste Low Density Polyethylene is shown in Figure 3.3. Here the fibre loading led to continuous drop in flexural strength. The maximum flexural strength was when fibre loading was 17 %. Danladi *et al*. [14] reported a flexural strength of 58.68 at fibre loading of 27 % using polypropylene as a matrix. The composites revealed that the maximum flexural modulus is attained when the fibre loading is 26 %. This means that for good result in terms of materials design, the fibre loading should not be less than or greater than 26 %, as shown in Figure 3.4.

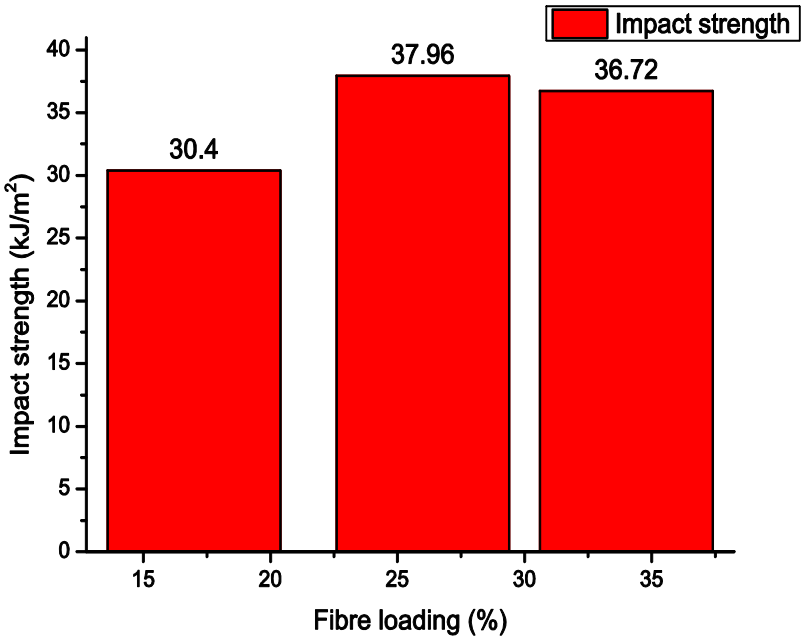


Figure 3.5: Effect of Jute-fibre loading on impact strength of Waste low-density Polyethylene composite

3.3 Impact strength

The impact strength of the composite is shown in Figure 3.5. The results showed that the impact strength is preeminent when fibre loading is 26 % (37.96 kJ/m^2. Dugvekar and Dixit [5] reported 43.25 kJ/m^2 for 15 % rice husk and 15 % jute reinforced High Density Polyethylene Composite, the higher value here is due to hybridisation. Danladi *et al* [14] reported an impact strength of 8.61 kJ/m^2 using polypropylene, this is because low density polyethylene is more elastic than polypropylene though both are thermoplastic.

3.4 Physical Properties

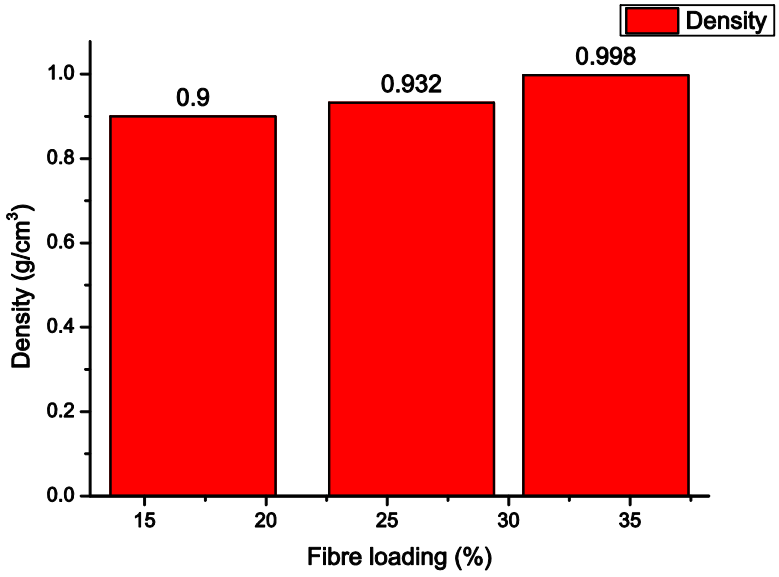


Figure 3.6: Effect of Jute-fibre loading on density of Waste low-density Polyethylene composite

The density increased with increase in fibre loading almost in a linear pattern. This implies that increase in fibre loading also leads to increase in density of the composite. The findings of Danladi *et al* [14] showed similar results with the present result.

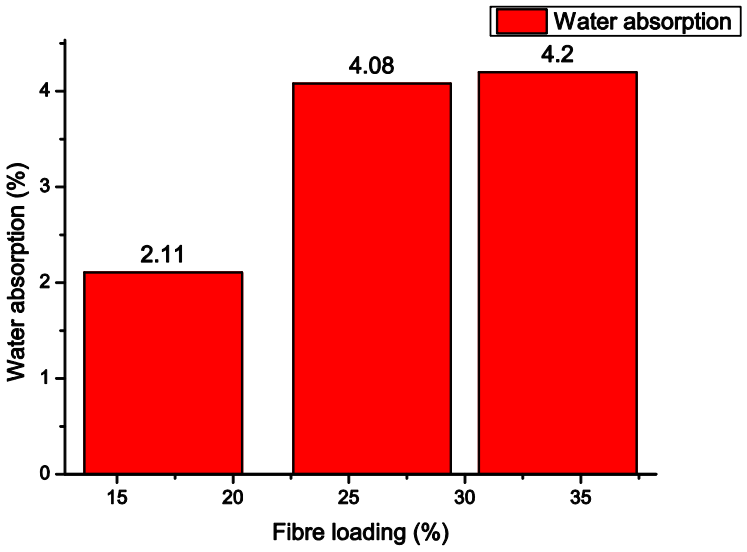


Figure 3.7: Effect of Jute-fibre loading on water absorption of Waste low-density Polyethylene composite

The water absorption after immersing the samples in water for 24 hours, is shown in Figure 3.7. The results showed a continuous increase in water absorption as the fibre loading increases, this is due to the hydrophilic nature of jute fibre. Inegbedion *et al*. [13] had highest water absorption at filler loading of 50 %, Bhuiyan *et al*. [8] reported higher water absorption than the current work, this could be attributed to better fibre – matrix adhesion in the present work than the reported work by Inegbedion *et al*. [13] and Bhuiyan *et al*. [8] respectively.

4.0 Conclusions

Preparation, characterisation, and fabrications results from low waste density polyethylene into useful reinforced composites materials was carried out successfully. The material possesses good characteristics: Tensile strength was best at fibre loading of 26 % (23.36 MPa) and flexural strength at fibre loading of 17 % (22.12 MPa). The impact strength was best at fibre loading of 26 % (37.96 kJ/m^2). The density and water absorption increases with increase in fibre loading in a steady manner; 0.998 g/cm^3 (34 %), 4.2 % (34 %) respectively. It was found that the reinforced composites materials displayed excellent mechanical strength suited for large structural materials for interior application in automobile.

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