WATER ABSORPTION AND FLAMMABILITY PROPERTIES OF WATER HYACINTH *(Eichhornia crassipes)* FIBRE REINFORCED THERMOPLASTIC COMPOSITE

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Natural fibers are considered the foremost alternative to synthetic fibres due to their comparatively lower environmental impact. The water hyacinth *(Eichhornia crassipes)*, an invasive aquatic weed is a potential source of natural fibres for various applications. The study focused on the use of water hyacinth fibres (WHF) as a reinforcing phase in a Polyethylene (PE) matrix, where the PE material was obtained as waste packaging material from an industry. The WHF were extracted using a decorticating process and added to the PE matrix at varying rates of 0, 5, 7.5, 10 and 12.5 w/w%. The composites were manufactured using a compression moulding technique and developed without the use of any chemical additives. Moisture absorption and flammability tests were conducted on the prepared composites according to ASTM D 570 and UL-94 Horizontal Flame Propagation test, respectively. The results showed that the 5% WHF composite had the lowest water absorption compared to the other WHF reinforced composites while the control sample (0% WHF) had the lowest water absorption overall. However, the water absorption value of the polyethylene (PE) composite reinforced with 12.5% WHF was found to be significantly lower, at only 2.5%, compared to that of commercially available wood particle board, which absorbed water at a rate as high as 80% in 72 hours. Moreover, the burning rate increased with an increase in WHF content. However, it is necessary to conduct mechanical experiments to assess the viability of utilizing water hyacinth fibre composites in non-structural applications, particularly, in the development of panel boards.

Keywords: Water hyacinth fibres, composites, polyethylene, moisture absorption, flammability.

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1. INTRODUCTION

The utilization of natural fibres as reinforcement for polymer-matrix composites has gained popularity owing to their potential to the mitigate environmental impact. The low density, high specific strength and stiffness of natural fibres make them desirable for their incorporation in fibre-polymer composites (Pickering et al., 2016). It is demonstrated that natural composites are extensively employed in the fabrication of diverse automotive components, primarily due to their cost-effectiveness, environmental sustainability and biodegradability (Tewelde et al., 2022).

Water hyacinth *(Eichhornea crassipe)* is a floating aquatic plant considered as an invasive weed due to its negative impacts on oxygen levels, fisheries and irrigation and transportation systems. Nonetheless, several research studies have demonstrated that water hyacinth can serve as a valuable fibre resource for various applications due to its advantageous properties (Nawal Huda et al., 2017). Water hyacinth fibres (WHF) contain lignocellulosic components, including cellulose, hemicelluloses and lignin. Recent studies indicate that WHF possess a higher cellulose content (36-43%) than coir fibre (Abral et al., 2013). Additionally, WHF exhibit both toughness and flexibility (Arivendan et al., 2022), and contain a higher percentage of holocellulose compared to other fibres, making them ideal for use as a reinforcement. The stem of the water hyacinth plant is the primary raw material utilized in the production of fibres.

The objective of this study was to produce a polymer composite utilizing WHF as the reinforcement, and to investigate the physical properties of the resulting composites, specifically, water absorption and flammability properties. Previous studies have emphasized the importance of evaluating water absorption properties as a fundamental physical test for materials intended for exterior applications (Saba et al., 2018). The mechanical decortication technique was utilized to extract the WHF from the stem of the plant, and various weight percentages (0%, 5%, 7.5%, 10%, and 12.5%) of the extracted fibres were incorporated into a polyethylene (PE) matrix as the reinforcing phase.

2. METHODOLOGY

Used polyethylene bags were collected from an industry. Fresh water hyacinth plants were harvested from a nearby stream adjacent to the *Karadiyana* compost plant in *Boralesgamuwa*. Utilizing a decorticator machine, the water hyacinth fibres (WHF) were extracted from fresh stems and then dried in a hot air oven at 105°C until a constant weight was achieved. The fibres were subsequently cut into 1-2cm lengths and interposed between PE layers. Finally, a laminating machine was employed to prepress the sheets at 140°C for 10 minutes. The pre-pressed sheets were again shredded using a crushing machine. The crushed WHF-PE particles were laid in a mould and compressed using a hot press at 150°C (upper plate), 160°C (Lower plate) for 15min. The cooling time was 10min.

2.1. MOISTURE ABSORPTION

To assess the water absorption properties of the produced composites, ASTM D 570 was employed. The percentage of water absorption was determined using,

$$\text{Equation 1: } \textit{water absorption} = \frac{W_n - W_d}{W_d} \times 100$$

Where W_n represents the weight of composite samples upon immersion and W_d represents the weight of the composite samples before immersion.

2.2. FLAMMABILITY

To evaluate the flammability performance of the composites, the UL-94 Horizontal Flame Propagation test was conducted, as per previous studies (Echeverria et al., 2019). The specimens utilized for this test measured 120mm x 10mm x 3.2mm in size and were marked with two lines, positioned 25mm and 100mm from one end of the sample. A contact flame was applied at a 45° angle and held for 30 seconds, after which the burning rate was recorded.

3. RESULTS AND DISCUSSION

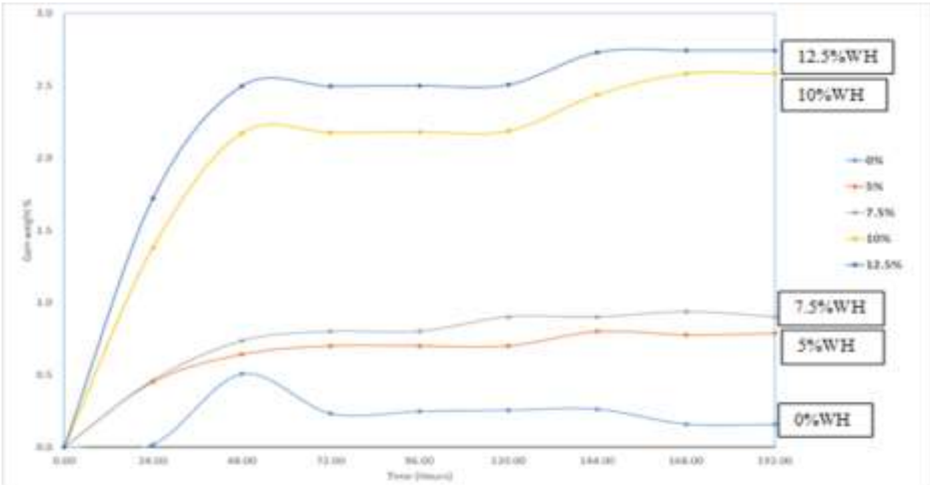

Figure 1: Moisture absorption percentage of water hyacinth fibre-reinforced thermoplastic composite with different weight percentage of water hyacinth fibres vs time (hours)

The findings indicate that the rate of water absorption initially increases in the first two days (0-48 hours) and then gradually reduces when the equilibrium state is attained. It was observed that the equilibrium state was reached after 168 hours. The results have shown that the WH fibre reinforced thermoplastic composites absorbed a higher amount of water than the unreinforced matrix (0 wt. %). The moisture absorption characteristics of natural fibres are contingent upon multiple parameters, such as the chemical composition of the fibres, which includes hemicelluloses and lignin, the presence of hollow cavities, the permeability of fibres, the presence of surface protection and the diffusivity of fibers (Alsubari et al., 2021; Azwa et al., 2013). Based on the results of this current study, it can be inferred that an increase in the water hyacinth fibre content results in a corresponding increase in moisture absorption, primarily due to the aforementioned parameters.

However, it is worth noting that the water absorption value of the polyethylene (PE) composite reinforced with 12.5% water hyacinth fibres (WHF) was found to be lower than that of commercially available wood particle board (Hamouda et al., 2019). According to the reference, the water absorption percentage of commercially available wood particle board was around 80% in 72 hours and 15% wool waste and 85% tetra pack hybrid composite's water absorption rate in 72 hours was around 30%. According to these data of reference, the current research study reveals that the composite reinforced with 12.5% water hyacinth fibers exhibits the lowest water absorption rate, measuring at only 2.5% over a 72-hour period.

Table 1: Results of flammability tests performed on PE thermoplastic composites using various weight compositions of WH fibre reinforcement

Sample name with WH fibre weight percentage	Burning rate (mm/min)
O% WH	28.7
5% WH	30.9
7.5% WH	31.5
10% WH	31.4
12.5% WH	31.6

Based on the findings, it was observed that the burning rate of composites reinforced with WHF increased proportionally with increasing weight percentage of the fibres. Furthermore, the burning rates of the WHF reinforced composites were higher than those of the unreinforced matrix.

4. CONCLUSIONS/RECOMMENDATIONS

The experimental findings indicate a positive correlation between the amount of water hyacinth used as reinforcement in PE composites and their water absorption and flammability properties. However, it was observed that the water absorption of the polyethylene (PE) composites reinforced with 12.5% WHF exhibited lower values than those of commercially available wood particle boards. The high flammability property of these composites suggests that the use of flame-retardant additives is necessary to delay the burning rate. Further investigations are currently underway to assess the suitability of water hyacinth fibre composites for non-structural applications such as panel boards.

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