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Modelling and optimization of the absorption rate of date palm fiber reinforced composite using response surface methodology

Riyadh Benyettou [a,b], Salah Amroune [a,b], Mohamed Slamani [a,b], Khalissa Saada [a,b], Hassan Fouad [c,*], Mohammad Jawaid [d,*], S. Sikdar [e]

[a] Department of Mechanical Engineering, Faculty of Technology, University of M'sila, Algeria
[b] Materials and Structural Mechanics Laboratory (LMMS), University of M'sila, Algeria
[c] Department of Applied Medical Science, Community College, King Saud University, PO Box 10219, Riyadh 11433, Saudi Arabia
[d] Laboratory of Bio Composite Technology, Institute of Tropical Forestry and Forest Products (INTROP), University Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[e] Department of Engineering and Technology, School of Computing and Engineering, University of Huddersfield, HD1 3DH, United Kingdom

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ABSTRACT

The aim of this work to explore the absorption behavior of bio composites reinforced with date palm fibers. RSM and ANOVA were utilized to evaluate the impact and interdependence of input variables (Time: from 24 h to 672 h, Fiber content: 15 %, 20 %, and 25 %, and types of water: seawater, distilled water, and rainwater) on the output variables (Mass of CDPF) during a water absorption process that lasted more than 670 h at 23 °C. The findings revealed that the bio composites with the above-mentioned filler content absorbed more water as the amount of fibers increased, with absorption rates of 14.03 %, 19.39 %, 30.94 % for seawater, 15.42 %, 20.64 %, and 36.08 % for distilled water, and 16.37 %, 21.98 %, and 42.10 % for rainwater, respectively. Additionally, the study measured the diffusion coefficient of bio composites, which had a minimum value of about $2.11 \times 10^{-6}mm^2/s$ and a maximum value of about $3.99 \times 10^{-6}mm^2/s$. The results of RSM model analysis showed that this model is accurate and reliable. Where the values of R^2 and adjusted R^2 coefficients for the Mass of CDPF were 99.63 % and 99.61 %, respectively, indicating an ideal match between experimental and predicted values. These findings provide valuable information for engineers interested in incorporating date palm fiber bio composites during development and implementation.

1. Introduction

Recently, most researchers have focused on studying the properties of bio composites because they have many advantages over traditional materials such as fiberglass-based composites or metallic materials. They are generally lighter, easier to produce and use, and have a lower environmental impact. Bio composite materials can also be made from renewable sources and are generally biodegradable, making them more environmentally friendly [1–3]. Bio composites are used in a wide variety of applications, from construction and packaging to automobiles, planes and ships [4–7]. As these bio composites come into direct contact with weather elements like rain, and humidity, it is crucial to examine their water absorption behavior. Therefore, this current work focuses on studying and analyzing the water absorption behavior of palm fiber reinforced composites.

As mentioned earlier, in contemporary times, bio composites enriched with plant fibers such as kenaf, jute, coir, hemp, sisal, ramie, flax, sugarcane, coffee, rice and palm [8–19] fibers are receiving great attention as an alternative to synthetic fibers. Where many studies have focused on the phenomenon of absorption of bio-composite materials reinforced with cellulosic fibers, among these studies: Tezara et al. [20] examine the mechanical properties and water absorption behavior of epoxy composites reinforced by jute-ramie hybridization. The results showed that the hybrid composite had better performance compared to the pure jute composites, despite a reduction in mechanical properties after exposure to water. They indicated that the appropriate stacking sequence and material selection are crucial factors that affect the properties of the composite, The highest percentage increase in weight was observed in the following order (where R represents Ramie and J represents Jute): Jute had the highest percentage gain weight (8.10 %), followed by RJJJR (8.02 %), JRRRJ (8.01 %), JRJRJ (7.93 %), RJRJR (7.90 %), and RJRJ (7.57 %). More recently. The study on the

* Corresponding authors.
E-mail addresses: menhfef@ksu.edu.sa (H. Fouad), jawaid@upm.edu.my (M. Jawaid).

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