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Potential of Coconut Coir as an Environmentally Friendly Wet Floral Sponge

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Abstract

Wet floral foam commonly used in flower arrangements, has a negative environmental impact as it is made of non-biodegradable plastic material that can break down into microplastics. This study explores the development of an environmentally friendly floral sponge formulated from a blend of coconut coir and polyurethane. Coconut coir a natural resource, was selected for its biodegradability and water retention properties, while polyurethane was used as a binding agent to enhance structural integrity. The research employed three different ratios of coconut coir to polyols to diisocynates which were 0.5:1:1 (Sample A), 1:1:1 (Sample B) and 2:1:1 (Sample C). Each sample was subjected to ASTM D570 water absorption test and ASTM E96/E96M water evaporation tests to determine its effectiveness as a floral sponge. Results revealed, as the coconut coir ratio increases, the absorption rate increases but the absorption percentage drops. Coconut coir contributes its natural hydrophilic and capillary structure, allowing effective moisture wicking and retention. While polyurethane adds porosity and increases the material's surface area for trapping water. In term of evaporation, increasing the ratio of coconut coir enhances evaporation rates due to its fibrous texture and larger porous structure, which increases the surface area for water exposure and promotes faster evaporation. In conclusion, the findings suggest that a balanced formulation of coconut coir to polyurethane 1:1:1 (Sample B) can yield an effective and environmentally friendly floral sponge. This biodegradable alternative hold promises for reducing plastic waste in floral arrangements, offering a viable substitute to traditional floral foam without compromising on performance.

Keywords **:** *Wet floral sponge; Coconut Coir; Polyurethane; Environmentally friendly; Absorption; Evaporation*

I. INTRODUCTION

A wet floral sponge, often referred to as floral foam, is a specialized material widely used in floral arrangements to provide structural support and water to cut flowers. This sponge is made from a dense, lightweight foam that has been specifically designed to absorb and retain water. The wet floral sponge is essential in creating fresh flower arrangements that need to stay hydrated and maintain their appearance for an extended period.

The equivalence of each block of commercial floral sponge to the weight of around 10 single-use plastic bags highlights its significant environmental impact, as widespread use contributes to the accumulation of non-biodegradable waste, exacerbating microplastic pollution in ecosystems and posing long-term threats to wildlife and soil health.

The accumulation of coconut coir waste in Malaysia has become an environmental and resource management challenge due to the country's significant coconut production. This waste, primarily comprising husks and fibers, often ends up in landfills or is burned, contributing to air and land pollution.

Addressing by these two issues, this research is focusing on studying the potential of coconut coir as an environmentally friendly wet floral sponge. Coconut coir was selected for its biodegradability and water retention properties, while polyurethane was used as a binding agent to enhance structural integrity.

Three different ratios of coconut coir to polyurethane were used in this research to determine its potential based on water absorption and water evaporation rate. Those two tests will be using the American Society for Testing and Materials, now known as ASTM International. It is a globally recognized organization that develops and publishes voluntary consensus technical standards.

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II. LITERATURE REVIEW

This chapter focus on a few studies are that being focused in developing the research which are on wet floral sponge, coconut coir and ASTM for water absorption and water evaporation.

A. Environmental Effect of Floral Sponge

Commercial floral sponges are manufactured with formaldehyde-based chemicals, which can cause skin irritation upon contact. Moreover, the environmental impact of these synthetic sponges is estimated to be approximately 100,000 tons of floral foam are produced globally each year, much of which is not biodegradable, contributing to long-term environmental pollution. [1]

The production process itself also generates significant greenhouse gas emissions. For example, studies suggest that the carbon footprint of producing a kilogram of floral sponge is around 2.5 kg of CO_2 equivalents. [2]

B. Environmental Effect of Coconut Coir

According to research issued in 2023, coconut trash accounts for around 6.7% of total agricultural waste generated in Malaysia. This equates to a significant volume of 80,000 tonnes of coconut coir produced yearly. [3] The inappropriate disposal or underutilization of coconut coir can have serious environmental consequences. The accumulation of organic waste, such as coconut coir, can lead to pollution, soil deterioration, and habitat damage.

C. ASTM Water Absorption and Water Evaporation

Water absorption tests measure the amount of water a material absorbs under specified conditions. In this research, ASTM D570 - Standard Test Method for Water Absorption of Plastics was used. [4] The percentage of water absorption is calculated as follows:

$$Water\ Absorption(\%) = \frac{Wet\ weight - Dry\ weight}{\text{Dry Weight}}\ x\ 100$$

ASTM standards related to water evaporation typically focus on measuring the rate of evaporation, vapor transmission, or drying properties of materials in controlled environments. In this research, ASTM E96/E96M – Standard Test Methods for Water Vapor Transmission of Materials was used. [5]

III. RESEARCH METHODOLOGY

A. Sample Preparation

Three different ratios of coconut coir to polyurethane were used in this research as shown in Table 1 below:

Table 1: Different Formulation Ratio

Sample	Coconut Coir	Polyols	Diisocyanates
A	0.5	1	1
B	1	1	1
C	2	1	1

All the material was mixed in a proper mold to ensure a good shape of the sponge according to the ratio. The samples were lest to dry for a certain period to let it fully polymerize and then was cut into 3x3x3 inch sample size.

Figure 1: Different ratios of coconut coir samples

B. Water Absorption Testing Procedure

The dried sample was weighed and recorded. It is then immersed in water for 24 hours at room temperature. After 24 hours the sample was removed, surface water was wiped off, and the sample is re-weighed. The final weight was recorded and the water absorption was calculated with the given formula. [4]

C. Water Evaporation Testing Procedure

ASTM E96/E96M specifies test methods to measure the water vapor transmission rate (WVTR) of materials. Continuously after weighing the sample from the absorption test, the sample was placed in a controlled environment with room temperature and humidity. The sample was avoided from being exposed to direct sunlight. The sample was left to dry for 12 hours. After that the sample is re-weighed. The weight change of the sample was recorded over time to calculate water vapor transmission. [5]

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Figure 2: Close-up sample C structure

IV. RESULT AND DISCUSSION

Table 2: Water Absorption Result

Sample	Percentage (%)				Absorption Rate (g/h)			
	1st	2nd	3rd	Average	1st	2nd	3rd	Average
A	530.66	537.95	406.84	491.82	2.02	2.18	3.05	2.42
B	982.76	1051.27	842.31	958.78	3.40	3.33	4.23	3.66
C	302.67	195.95	188.24	228.95	4.44	3.69	4.01	4.05

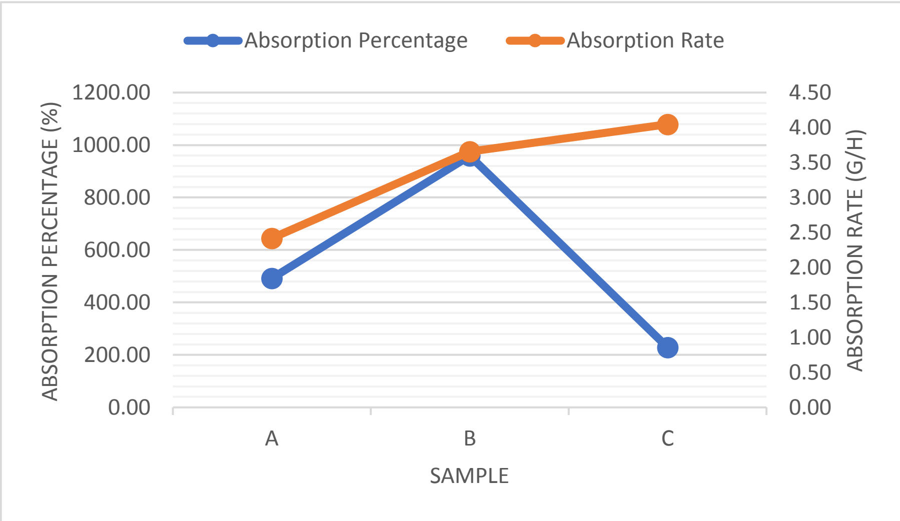

Figure 3: Graph of Absorption Percentage and Rate

Table 3: Water Evaporation Result

Sample	Percentage (%)				Evaporation Rate (g/h)			
	1st	2nd	3rd	Average	1st	2nd	3rd	Average
A	13.29	17.84	7.87	13.00	0.64	0.92	0.60	0.72
B	12.24	10.98	17.20	13.47	0.92	0.80	1.63	1.12
C	23.10	22.32	23.94	23.12	2.73	2.49	2.94	2.72

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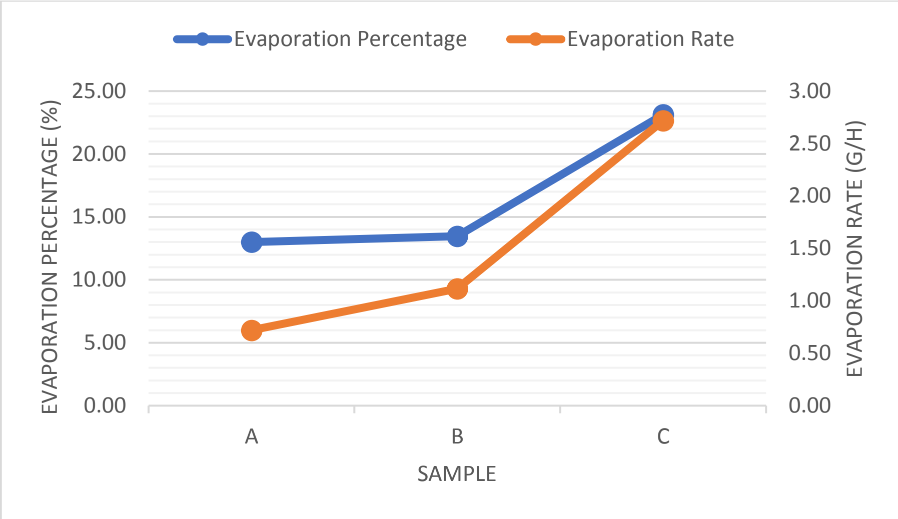

Figure 4: Graph of Evaporation Percentage and Rate

A. Water Absorption

The mechanism of absorption involves the transfer of molecules or particles from a bulk phase into the surface or interior of another substance. In the case of sponges, the material absorbs water into its porous structure, which traps and retains the liquid. [6]

According to the experimental data, Sample B demonstrated the highest absorption performance at the balance ratio of coconut coir to polyols to diisocynates at 1:1:1. While for absorption rate, the higher the coconut coir ratio, the higher the absorption rate was observed.

Based on the experiment, it can be stated that blending natural fibers like coconut coir with synthetic polymers can enhance water absorption as coconut coir is generally hydrophilic, meaning it absorbs and retains water well. Coconut coir, made from the fibers of coconut husks, has excellent water retention properties due to its natural capillary structure, which allows it to wick moisture effectively. [7] In addition, the presence of polyurethane creates a highly porous structure like sponges that increases the surface area and the ability to trap water within the material. The interconnected pores allow water to penetrate and be retained within the matrix. [8]

Apart from that, as the coconut coir ratio increases, the absorption rate increases but the absorption percentage drops. This is the drawback of coconut coir as it appears to allow for a larger porous structure, contributing to its limitation to absorb more water despite its hydrophilic properties. Sample B, with a balanced ratio of 1:1:1, demonstrates an optimal combination of structure and the hydrophilic properties of coconut coir, resulting in a high absorption percentage and rate.

B. Water Evaporation

Evaporation is a process in which liquid turns into a vapor at temperatures below its boiling point. During evaporation, molecules at the surface of a liquid gain sufficient energy to break free from the intermolecular forces holding them in the liquid state and enter the gaseous phase. [9]

Based on the data obtained, it shows that as the ratio of coconut coir increases, the evaporation percentage and evaporation rate increase. The water evaporation among each sample can be explained by examining their material composition, structural properties, and the interaction between coconut coir and polyurethane in each formulation.

As the ratio of coconut coir increases in the sample, it has a higher evaporation rate because the fibrous texture of coconut coir increases the surface area exposed to air, promoting faster evaporation as more water molecules have the opportunity to escape into the atmosphere. [10] This statement can be proved by observing the structure of the sample as Sample C with ratio 2:1:1 has a larger porous structure compare to other sample structures.

In contrast, Samples A (0.5:1:1) and B (1:1:1) likely contain a more balanced ratio of polyurethane to coconut coir, creating a denser, less porous structure that retains moisture longer. The polyurethane in these samples forms a network that reduces evaporation pathways, slowing down water loss.

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The differences in evaporation rates also reflect the distinct roles that polyurethane and coconut coir play in these compositions. Coconut coir offers excellent absorption due to its hydrophilic properties but provides limited structural support, resulting in larger porous structures that increase the rate of evaporation. In contrast, polyurethane functions as a semi-barrier to water movement, effectively reducing evaporation.

This property is especially advantageous in applications where extended moisture retention is needed, as it reduces the need for frequent water replacement in floral arrangements. Therefore, a balance ratio 1:1:1 as demonstrated by Sample B show promising formulation for an environmentally friendly wet floral sponge.

V. CONCLUSION

The study demonstrates that blending natural fibers like coconut coir with synthetic polymers such as polyurethane enhances water absorption properties. Coconut coir contributes its natural hydrophilic and capillary structure, allowing effective moisture wicking and retention, while polyurethane adds porosity and increases the material's surface area for trapping water. The optimal balance between these components is crucial, as higher coconut coir ratios increase the absorption rate but reduce the overall absorption percentage due to structural limitations. The experiment also demonstrates that the evaporation rate and percentage are influenced by the ratio of coconut coir to polyurethane, reflecting the distinct roles of these materials in the composite. Increasing the ratio of coconut coir enhances evaporation rates due to its fibrous texture and larger porous structure, which increases the surface area for water exposure and promotes faster evaporation. Thus, a balance ratio between coconut coir and polyurethane which is exhibited by Sample B is critical to achieving desired absorption and evaporation characteristics, making these composites versatile for applications requiring controlled moisture retention and release such as in wet floral sponge.

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